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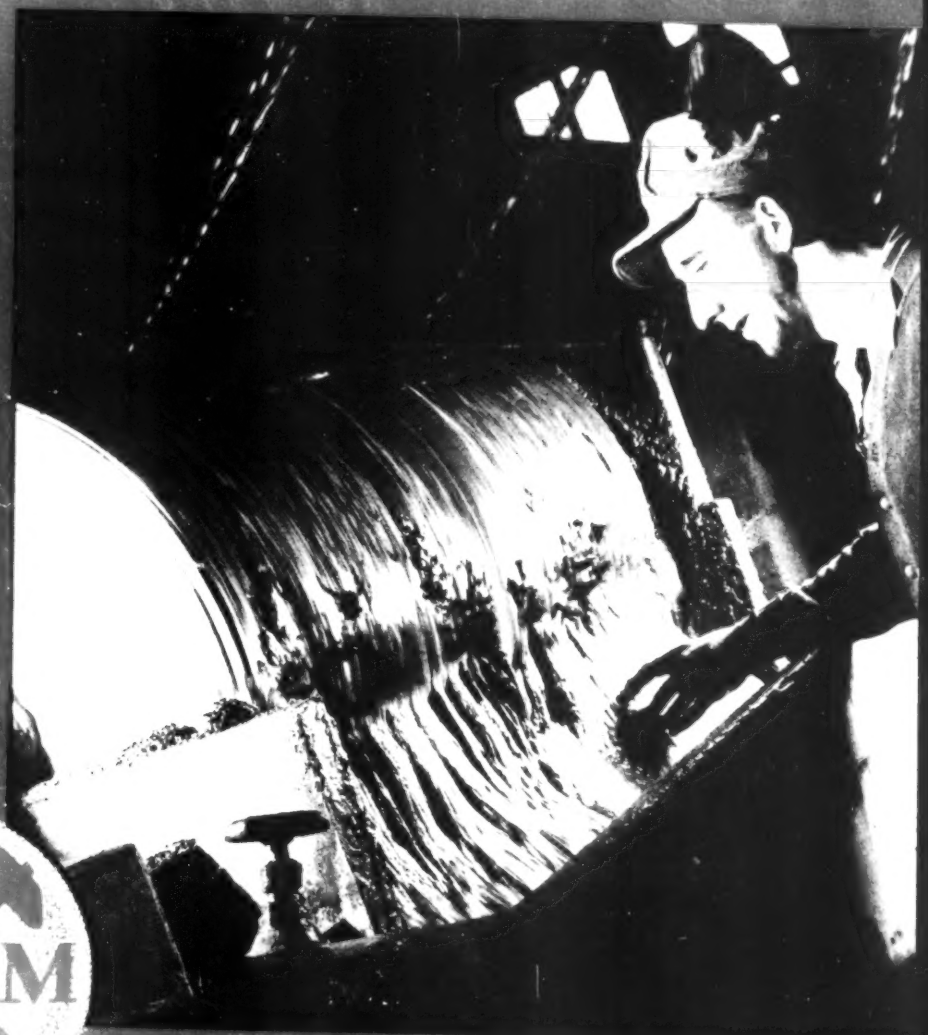

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AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS
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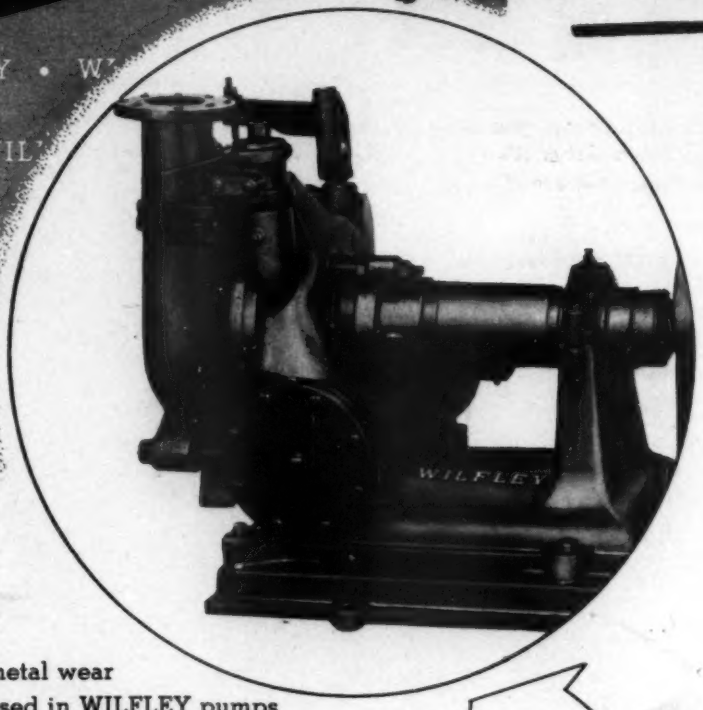

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MINING ENGINEERING

In which is incorporated Mining and Metallurgy, Mining Technology and Coal Technology

APRIL 1949 VOLUME I, NO. 4

Cover photograph shows a magnetic separator in operation.

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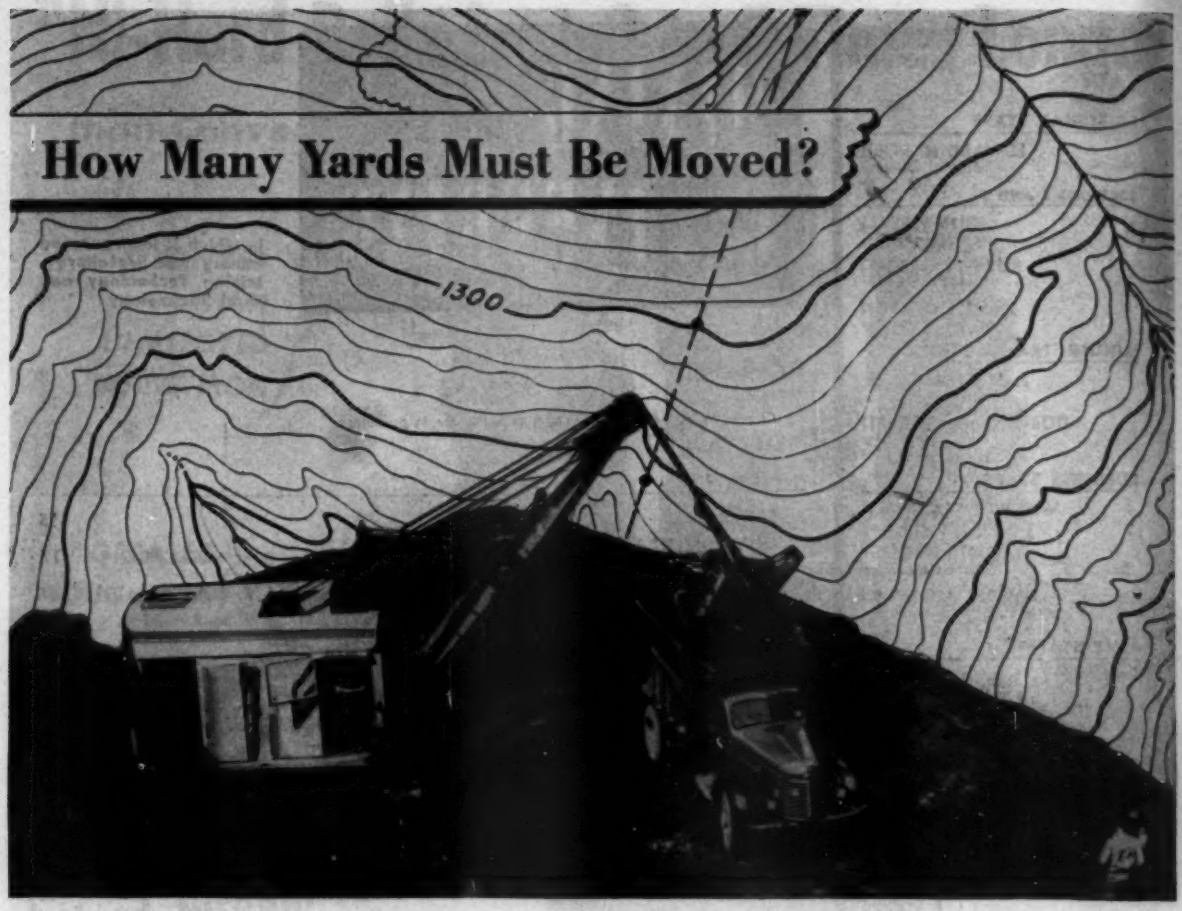

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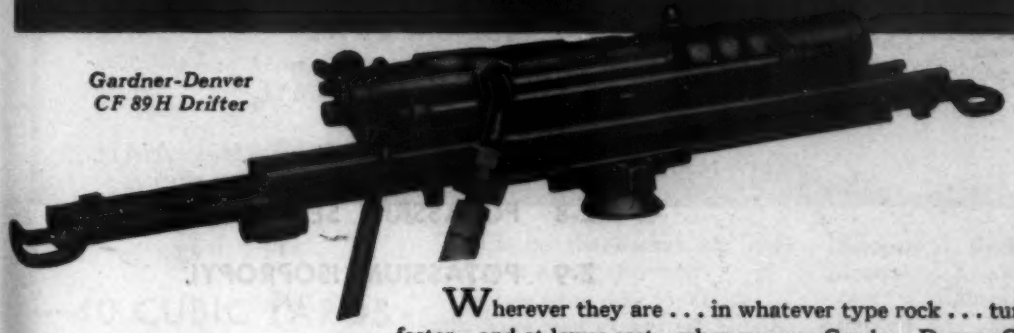

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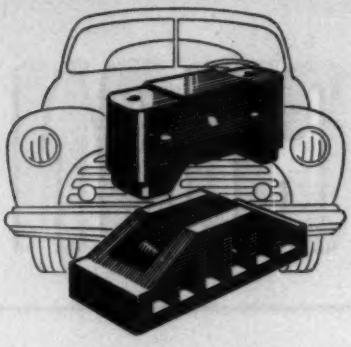

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Letters to the Editor

Advanced Degree Problem

Our editorial, "Advanced Degrees and the Mining Engineer," in the February issue of MINING ENGINEERING *has elicited the following comments:*

I am still undecided as to the merit of the recent editorial. At first I was somewhat alarmed and upset, but after a cooling-off period I began to understand, to a certain extent, your point of view.

Advanced degrees for mining engineers are not uncommon these days. Whether or not there is need for them is a debatable question. The young Ph.D. referred to in the editorial most certainly was aware of the limitations for a mining engineer engaged in a large scale mining operation. My guess is that he will leave the mining profession for another branch of engineering or science, or he will eventually enter the teaching profession.

In recent years universities and technical colleges have shown a preference for men with Ph.D. degrees for their staffs. They have placed degrees far ahead of practical experience. Men with many years of practical experience seldom leave industrial positions to accept low-paying teaching jobs. On the other hand, highly educated men will not spend years gaining experience by starting at the bottom with routine jobs.

Since the war, every major technical magazine has featured articles concerning education and industrial training for young engineers. Many words have been spent on these subjects, but few concrete results have been seen. The schools continue to train the students one way and industry continues to ignore this training and substitute a haphazard system of its own. Perhaps a joint board of educators and industrial managers should be formed to establish an educational program that would turn out engineers equipped for decent jobs with industry or for teaching positions. Then, too, the professional engineers' registration laws may have some effect.

K. G. ACKERMANN
Berwyn, Ill.

. . . The apparently imposing problems connected with employment of Ph.D.'s in the mining industry posed some vital questions.

We might be obliged to agree that at present it is possible that there are few mining companies who can employ a mining graduate with a Ph.D., and use his knowledge and training to best advantage. On the other hand it is not difficult to see the vital need for men of this type of training in teaching and research, and in the application of the results of research.

In partial answer to your questions I would like to offer some questions of my own:

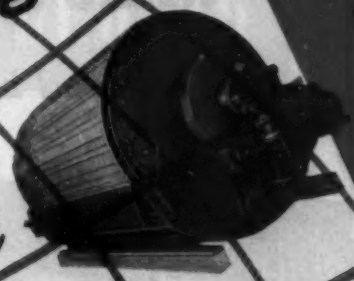
How many mining engineers have sufficient background in higher mathematics, physics, elasticity, plasticity, geology, chemistry, etc., to attempt to solve the problems of stresses around mine openings, of rock bursts, of the scientific discovery of new ore bodies, of the physics of the solid states of materials of the earth's crust, of the improvements in uses and understanding of explosives, etc.? Who is to carry on the pure and applied research which must be done in mining in order that it may keep abreast of other branches of engineering? How much longer must we depend upon Ph.D.'s in physics, mathematics, and chemistry to do the majority of our fundamental research in mining? Is it not important that we have men engaged in mining research who have a well-balanced background in both mining education, experience, and higher education in order that they may establish the relationships which must exist between laboratory and field research and their useful application?

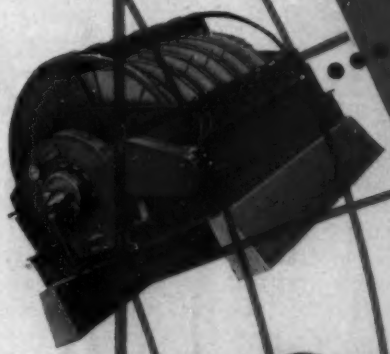
It must be agreed that there is no substitute for experience in any field of endeavor. On the other hand, there is no substitute for knowledge of advanced theoretical physics, mathematics, etc. To point out the tragedy which would have occurred during the last war if our scientists had not possessed advanced theoretical knowledge as well as industrial know-how is to point out a simple but tremendously important fact. Is not the same principle applicable to mining engineering?

GEORGE B. CLARKE
Assistant Professor of
Mining Engineering
University of Illinois

(*Continued on p. 44, Sect. 1*)

The Tonnage of the WORLD'S Metal Mining Industry is filtered on





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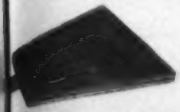

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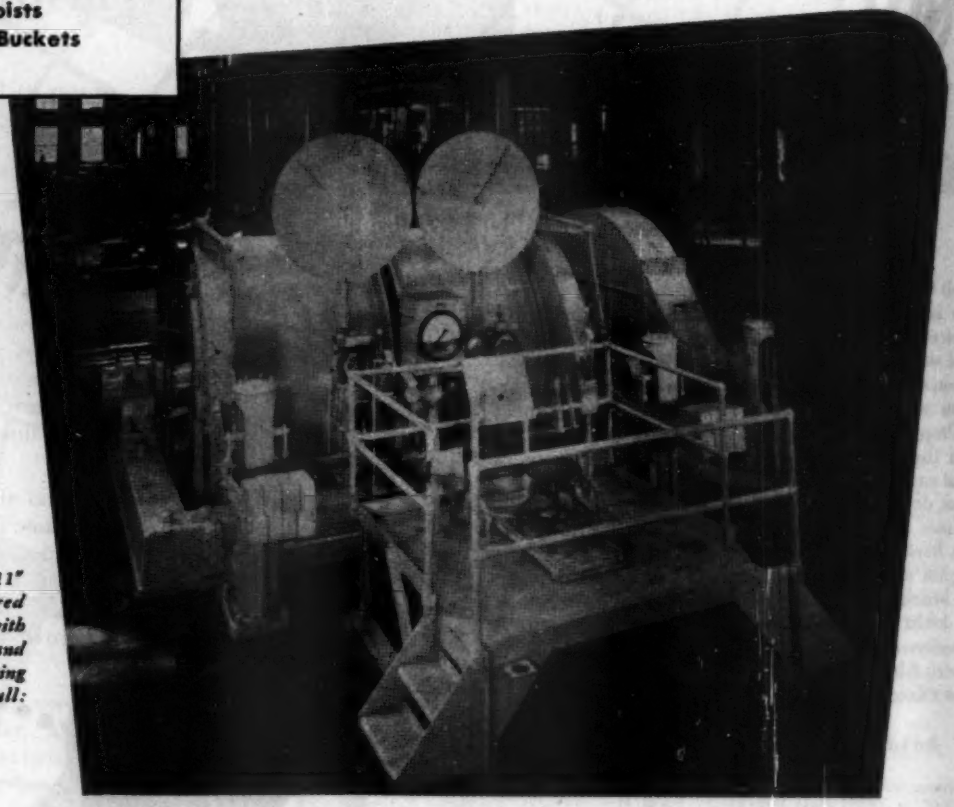

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XUM

MINING ENGINEERING

Don't Soil Your Hands With Politics!

Currently the mining industry is devoting a lot of time and money to influence Federal and State legislatures to its way of thinking as regards taxation, tariffs, premium prices, and union controls. This money and time seems to be put to work to do the job in two ways. The first of these, and time-honored under the democratic system, is to maintain lobbies in the legislatures. The second system is to give speeches at mining association meetings stating an individual's or company's stand on various legislative issues.

The trouble with the first of these is that the industry representative does not have much of anything to trade in the way of votes when he approaches the legislators. The only way the industry can get favorable consideration from a legislative body is by having men in that legislature who feel favorably to the industry. These men are selected by popular vote at the time the citizens go to the polls. Attempts after this time to sway the opinion of the lawmakers must be backed up by vote promises at the next election. Our lobbyists have their hands tied. The industry is afflicted with the same failing as the average private citizen. He thinks that campaigning for a politician will "soil his hands." If, in any mining state, we got out and pushed a few doorbells and solicited votes for the man we knew supported our views, the mining industry would not suffer so much from oppressive legislation.

One mining company has been giving its employes a percentage of the profits each month and when faced with the threat of *severance* taxation showed them just how much this tax would cut out of their monthly profit bonus. The tax problem was explained to the miners and it was suggested that they write their senator to oppose the severance tax bill. If this system were worked by enough people at the right times it would be the most effective way to protect the industry.

If the records of the candidates could be studied before each election and their position regarding the mining industry determined, the employes of the industry could be informed so that they would have the facts on which to base their choice of a candidate. After all, the workmen should be as much interested as their employers in the welfare of the industry that provides their livelihood.

Speeches on political matters before mining association meetings are not the best way to gain support or sway a legislature. In the first place the audience is usually in thorough agreement with the speaker; also they belong to the class of citizens who do not like to mix in politics. It would be better to present such talks before civic organizations. The mining industry has been too prone to keep its problems locked up within its bosom when it might better educate the public as to how the welfare of the mining industry affects the whole community, urging all voters in mining areas to apply pressure to their representatives for action favorable to the industry.

With the message carried to employes and to the general public more success should be gained than by lobbying and by talking to ourselves.

What Does the Mining Industry Offer the Young Engineer?

The attitude of the metal mining industry toward securing young men as future engineers, operators, and executives of the mining branch of the industry, as distinguished from the metals and petroleum branches, was clearly reflected at the Student Forum at the San Francisco Annual Meeting. Although three representatives of mining were present, not one pointed up the promising future which lies ahead for any capable young man who goes to work in that field and stays with it. Instead, there were reminiscences of the colorful and rugged past. The idea of a recent graduate's starting out on a "Mexican dragline" still seems to be prevalent. There is nothing basically wrong with such an attitude except that it will not attract today's graduate to the mining industry. The ranks of qualified mining engineers coming up in the industry are thin, and relatively few are coming in at the bottom compared to the potentialities of an expanding industry beset with many problems of technology.

As shown by the poll taken at this forum, a vast majority of the seventy-odd students present were married veterans. They served their apprenticeship in a rugged school, and if they don't know something about human relations now, they won't learn it mucking in a mine, which seemed to be the principal reason offered for doing this type of work.

Possibly mining executives think this type of graduate temporary and that soon the pink-cheeked graduate of 21 summers will be back, instead of the grizzled veteran. But they may be rudely surprised. Why should a profession which promises relatively hard, dirty, dangerous work in out-of-the-way communities be more attractive than an engineering field offering clean, safe work in cultural surroundings? The glamour—the romance? They went out with the '49er, the Comstock, and the Klondike. Mining today is business on a large scale, heavily mechanized, working to fine tolerances imposed by low-grade ore bodies. The makeshift methods of the past are gone. With these changes has come a need for a different type of mining engineer. The mining industry needs highly trained engineers who can become specialists in any one of several recondite fields, or men with engineering background who are capable of handling the many problems of labor relations and economics. This industry is essential to the American economy and the highest calibre men are needed. But relatively little is done by most companies to encourage men to enter the field, and to ultilize their talents once the men are secured.

The San Francisco and El Paso student forums were ideal settings for telling future engineers what the profession has to offer. But from these two meetings, one might glean that the industry will accept a young man, and if he is not afraid of manual labor and works hard he will get along all right. This is a negative approach, but it has the virtue of being a reasonably true picture of the situation. However, it makes a young man wonder whether he did the right thing to study mining.

To be sure there are a few outstanding examples of fine industry training programs, but a lot of companies are kidding themselves that they are conducting such a program. Men are put to work in the mine for what is euphemistically called a "training period" but in reality forms a pool of college-trained men upon which the company may draw when it needs engineers. It may also be a "conditioning" period to see whether or not the man can "take it." Now there is still nothing wrong with starting the man in the mine. But watch him, encourage him, and move him as fast as he gets the feel of each job. And then when he knows how many holes it takes to break a round, and what it's like to "put in a shift" (and this need not take more than six months), pull him out and put him to work in a job that tests his capabilities as an engineer. The coal industry seems to be facing this problem. Training programs are well developed and an effort is made to reach the young man on the high school level as well as the college.

It should not be inferred that the young graduate of today needs to be pampered, or is not willing to do manual labor, for this is not so. Many students get their practical experience on summer jobs and by the time they graduate have benefited all they can from this type of work. Once he has begun work in his profession he wants to do productive work and be able to see where he's going. The metal mining industry has to jack itself up and recognize the fact that the glamour is in such things as nuclear physics and electronics these days, and that we are competing with these other industries for the cream of American youth.

To improve the quality of men entering the field, the industry must up-grade the job of the engineer. Because long periods as a miner were necessary in the old days, why mention it now that the picture has changed? A man can still start at the bottom and work up to the presidency of a big mining company. But that tree of success can be lost in the forest of drudgery. Why not give more impetus to the search?

California Does Big Business In Nonmetallics

Gold and sunshine are the two things that pop into one's mind at the mention of the State of California. The production of sunshine has been off somewhat last year but further than this we don't know what the dollar value would be. However, according to statistics in the "Mineral Information Service" bulletin published by the California Division of Mines, gold production grossed slightly over 14½ million dollars in 1948. The petroleum and natural gas dollar volume was close to a billion and is, by a wide margin, the biggest mineral producing commodity. The interesting thing in these statistics was the fact that the nonmetallic commodities amounted to more than 1½ million dollars, one third of which is accounted for by cement production; the total being about one sixth of the fuel production and seven times greater than the total metal production.

Government's Role in a National Mineral Policy

BY DONALD H. McLAUGHLIN • PRESIDENT, HOMESTAKE MINING CO.; MEMBER, AIME

Few factors have had more influence in maintaining the strength and stability of the United States than our persistent habit of providing checks and balances to the dynamic powers of free enterprise on the one hand and to the controls and guidance exercised by the State on the other. Indeed, it is this same concern for matching forces against each other that has given our republic its ability to preserve a democratic basis of life for its citizens, and yet maintain a government that is able to protect the rights of all and to resist and minimize the danger of excessive concentration of authority.

Our current efforts to clarify the nation's mineral policies and to define more clearly the role that the governmental agencies should play in conjunction with the functions of private enterprise again reveal the desirability and advantages of maintaining our traditional controls. At times, the equilibrium has been temporarily disturbed by too great enthusiasm for one or the other of these basic concepts. Sooner or later, however, the balance has been restored by the healthy opposition that is always created by excesses of one sort. At the current stage in our history, the swing toward undue enlargement of the powers of the State seems to have gone dangerously far and we would be untrue to our traditional behavior if the group that must demonstrate the virtues of free enterprise did not rally to its support with the utmost earnestness.

Undoubtedly, our system of competitive free enterprise has been highly successful in bringing about the present industrial strength of the country. And yet, if left unrestricted, it can and has, at times, led to omissions and abuses that are harmful to the nation. To correct these shortcomings is a recognized responsibility of the State, which in turn is not questioned except as to the degree that is desirable. To keep the vast strength of private enterprise under reasonable control without impairing its dynamic quality or endangering its survival is a proper objective of government within our system.

A particular responsibility falls upon those agencies of the government that deal with the mineral industries, for they are concerned with natural resources that are unavoidably depleted as the deposits are utilized. Their wise handling, in private as well as public lands, is of serious concern to the nation and the people as a whole. Neither wasteful exploitation nor neglect and indifference to opportunities can be tolerated.

It is the responsibility of the two principal agencies, the Geological Survey and the Bureau of Mines, to provide comprehensive data and to strive for leadership in research on scientific and technical aspects of exploration, exploitation, and utilization of minerals and fuels that are essential for active, efficient, and farsighted efforts on the part of private operators. Without the information they provide on available supplies, production, and consumption, both on national and international scale, decisions of most serious character would be dangerous guesses, inexcusable in peacetime and criminal in relation to defense.

mining laws examined

Mining laws should be revised so that, while preserving the system of patents and leases for their appropriate deposits, protection would be granted for an adequate period for those who assume the high risks of exploration, and simpler procedures established for acquisition of titles or leases on the part of those who have found adequate proof of the existence of valuable deposits to justify their serious development. Recommendations of such changes have been made in a report to the Hoover Commission that I hope will receive serious study when it is made public. With such improvements, the responsibility of the governmental agencies, such as the Bureau of Land Management with regard to legal procedures and documentation, and of the Geological Survey with regard to adequacy of exploration and other details, should be more clearly and sharply defined with benefits to all.

In general terms, the following points seem to me to provide a good basis for a national mineral policy: (1) preservation of conditions that keep the vast plants and organizations in the mineral industry functioning smoothly and efficiently in proper balance with the needs of the country; (2) utilization of reserves in known deposits without waste, not only in re-

lation to current demands but with recognition of probable future requirements; (3) aggressive exploration to discover and develop new sources of metallic ores, minerals, and fuels needed for the expanding economy of the nation and for protection in time of war; (4) continued support, on a reasonable scale, of efforts to develop operating mines and plants on noncompetitive deposits of scarce critical minerals within our own borders, as an insurance in case of interruption of foreign supplies, with output reserved in stock piles and operations held at a minimum to determine possibilities and to maintain plants in condition; (5) appropriate action to obtain from abroad whatever additional supplies are necessary for current needs and for insurance against shortages in times of emergency.

government restraints minimized

In meeting these objectives, the efforts of both private enterprise and government agencies are obviously required. To enable private enterprise to function most effectively, however, the major consideration needed from the government, at present, is restraint in imposing burdens rather than direct aid.

Avoidance of taxes so excessive that the funds remaining in private hands are inadequate for exploration, for maintenance, and for new equipment, on which the life of the mining industry depends, is the principal aid to ask from the government. Profits commensurate with the special risks are the vital incentives for free enterprise in mining; and this essential point should be recognized in the government's policies toward mining.

Other incentives, such as tariffs, subsidies, premium prices, or other doles, in my judgment, are thoroughly objectionable; but if the government continues to siphon off the profits that might otherwise remain in competent, successful, and aggressive private hands, such subsidies may have to be relied upon if exploration is not to stagnate. It is, however, a wasteful procedure to go through the expensive process of collecting money by taxation and handing it back in a selective way through necessarily complicated administrative procedures that at times may be dominated by officials more concerned with some currently popular social philosophy than with the realities of mining.

I recognize, however, that for emergency needs, such as preparation for war or actual war or to prevent the cost and suffering caused by shut downs in time of depression, special incentives of one sort or another may be called for.

reserves not short

We are all aware that the continent's endowment in ores of the common metals—iron, copper, lead, and zinc, and the important alloy metals, nickel and molybdenum, as well as in coal and petroleum—is a rich one, measured not only in terms of actual output but in prospects for maintenance of reserves. We are by no means a have-not continent in these major essentials, though we must recognize that the available supply in relation to our enormous consumption is none too large, and for some materials in this category, such as high-grade iron ores, lead, and zinc, the life of known reserves and the prospects for additional supplies are rather worrisome. Indeed, in no case is there any excuse for waste either in exploitation of the deposits or in use of the final products. The habits of the century of abundance that is past, with its many extravagances, can no longer be tolerated. The most effective way in which the situation will be met is and will be through higher prices for metals in a free market in relation to other commodities, thereby providing incentive for exploration and mining of lower grade ores, and the more efficient utilization of final products. The aid of government agencies in providing over-all data on scientific, technical, and economic character is wanted and needed, but little else, apart from proper tax policies. The good pattern set by the past record of the Bureau of Mines and the Survey in meeting these requirements gives every reason to expect that the industry will continue to have such essential and welcome services adapted and adjusted as conditions change and specific requirements contract or enlarge in importance.

plan for critical minerals

On the other hand, we are all aware of the many critical deficiencies that exist in our mineral endowment. At one extreme, as in the case of tin, we must recognize that we have no known deposits from which any significant quantity of material could be obtained; and that after years of intense search and study we must admit the prospects of finding such deposits are so poor that further expenditures seem unwarranted.

Between this extreme, however, and the case of those materials that we have in adequate quantity is a range of minerals that are in too scant supply to meet our needs fully. In the case of manganese and chromium, for example, we have a pretty fair idea of the quantity and quality of the deposits the continent affords and there is no reason to think that we could ever meet the huge needs of our industries for these vital metals from domestic mines. Deposits of their ores, however, are not entirely lacking and the insurance value of having mines and plants on the best of them—actual plants in being, and in operating condition—is worth the special expense necessary to create and support them. This would involve continued geologic and metallurgical investigations on the part of the Survey and Bureau. The actual equipment of mines and installation of plants on an operating scale should be left to private enterprise and to mining men induced to undertake such risks by provision of a guaranteed price over a sufficiently long period to enable such adventurers to make a profit.

In the case of manganese and chromium, only a rather small percentage of the nation's needs could be obtained by such a policy, and it should be recognized that the price would be high, but justifiable as insurance against shortages that might be disastrous. In the case of quicksilver, such a policy would undoubtedly lead to some new discoveries and to a small but possibly steady output capable of temporary expansion under emergency conditions. In the case of tungsten, I am more optimistic both as to the prospects for discovery and enlargement of existing mines and as to the chances for meeting a fair part of the country's need if such a procedure were followed.

As part of such a price policy, how-

ever, tariffs on such critical materials should be removed so that industry could be supplied currently from abroad, and development of foreign deposits would be encouraged, possibly and preferably by our own citizens, and as one of the means by which imports could be increased to obtain some return besides paper for our vast exports. The higher priced production of these scant products from domestic sources should be placed in stock piles and held for emergency needs. At worst, we would simply be converting our limited reserves in the ground into more readily accessible reserves above ground. At best, we might, in the course of this operation, relieve our needs by discovery of unexpected deposits or through improvement of metallurgical techniques find ways of making our meager resources go farther.

The policy as outlined above, i.e., (1) of direct and intensive exploration and development to pilot-mill stage by government agencies, and (2) of a guaranteed price to induce private groups to carry on from there, could be adapted to any mineral in notably scant supply. Incidentally, this policy would not exclude initiation of exploration or research by private agencies. Indeed a guaranteed price would encourage such efforts and the co-operation of the Survey and the Bureau, by making their scientific and technical knowledge as fully available as possible, would be of great value.

Enthusiasm for such laudable activities designed to augment domestic production, however, must not obscure the harsh realities. Each project must be reviewed and appraised coldly and the degree of our dependence on foreign sources must be recognized and taken into account. And in that connection, government agencies, including the armed forces and the State Department, have a serious responsibility to take all steps necessary to prevent the nation from being hampered or endangered by interruption of flow of vital minerals from abroad. Proper support should be given to Americans who, as individuals or in corporations, engage in mining and metallurgical enterprises abroad. Buying for stock piles should be careful and wise. Negotiation for some return for favors should precede the granting of them. All these should be elements of our mineral policy.

guaranteed prices

Another aspect of mineral policy is government support of a price in times of acute depression that would be adequate to keep at least the major mines and plants of the country in operation. Such prices should be uniform, though possibly some wide regional difference might properly be recognized. It should not be such that mines that are marginal under normal conditions are kept in operation. There will always be marginal mines, at any price. Such aid should be regarded solely as a means of supporting major communities by work instead of relief. Through it, the government would acquire valuable assets of metals at a low price which could be stocked against future emergencies and shortages, and the life and industries in important areas of the country would be relatively undisturbed.

Price floors, support of mines by buying for stock piles, and other subsidies can obviously become dangerous devices to rely upon too heavily; and my advocacy of them applies only to those minerals of which the country is clearly in short supply and as a means of providing some measure of relief in times of acute depression.

Bureau and Survey essential

In these days, when government expenditures have reached a level that seems fantastic in comparison with the well-ordered past, industry could hardly justify a cry for tax relief and at the same time request for new services requiring increased expenditures. By and large, the activities of the Geological Survey and the Bureau of Mines, at their present level, have met with wide approval. Their cost is moderate in comparison with that of such tremendous spenders as the Bureau of Reclamation, the Corps of Engineers of the Army, or the major agencies of the Department of Agriculture. Few of the activities of the Survey or the Bureau of Mines could be curtailed without loss and much of the fact finding and research could be expanded with real economies. Their achievements to date and their efforts to improve and enlarge their services deserve the approval and support of the mining industry. We should, however, urge that in conjunction with all new plans necessarily involving substantial expenditures, current activities be reviewed with the objective of eliminating or curtailing those that have served their purposes and are no longer essential.

The record of co-operation in the war was most satisfactory. Data provided by the two agencies was the main factor in leading to the initiation of many successful developments. Among such can be mentioned the efforts that led to the exploration of the San Manuel copper deposit some fifty miles north of Tucson, where over 425,000,000 tons of 0.8 per cent copper ore with some gold, silver, and molybdenum content was subsequently blocked out by the Magma Copper Co. At the Blackbird mine near Salmon, Idaho, the Howe Sound Co. found a substantial tonnage of cobalt-copper ore following drilling undertaken by the Bureau of Mines. Both the Survey and the Bureau deserve high credit for the investigations in the Metaline district in northeastern Washington that have led to most encouraging and timely developments there by private groups. In central Idaho, the Bradleys promptly utilized the results of the studies by the Survey and the initial drilling by the Bureau, thus giving the country its principal supply of tungsten during the war, and today its largest source of antimony.

While it is surely not the function of these agencies to undertake exploration activities of the thorough sort a mining company would regard as essential to establish the existence of ore, it seems reasonable for the Survey and the Bureau, under proper conditions, to employ such means as detailed sampling, trenching, drilling or even exploratory shaft sinking, in addition to their usual techniques. The Survey and the Bureau should be authorized to do such work where it is necessary to obtain the information they seek. They should be satisfied, however, with definite evidence to support ideas and possibilities for ore but not feel that they were called upon to provide the full data needed to establish commercial value in a complete

(*Continued on p. 39 in back of magazine*)

The Mystery of the Missing Man

a secret questionnaire to operators shows why a mine labor shortage exists

By JAMES K. RICHARDSON • MANAGER, UTAH MINING ASSOCIATION; MEMBER AIME

Do You Have All the Miners You Need?
Can You Keep the Ones You Have?
If Not, Check Your Personnel Policy Against These Questions.

(1) During the employment interview and afterwards do you make the applicant feel welcome and wanted?

(2) Have your supervisors been indoctrinated with a human approach in dealing with a man from the day he is hired until he leaves?

(3) Do your employes regard the boss as an unapproachable stuffed shirt?

(4) Do you tell your employes, in advance, of changes that are likely to affect them? (a machine can be moved without explanation but a man is liable to think he is being shoved around).

(5) When you provide change room, lunchroom, or any other facilities, do you recognize the man who is to use them as your best friend? Would you be willing to use them?

(6) Do you give credit and recognition to your subordinates?

(7) Does anyone ever contact sick or injured employes in your organization assuring them that their jobs are waiting for them?

(8) Are disciplinary measures administered in such an intelligent manner that you, personally, would be willing to submit to the same treatment?

(9) Does management get respect and maintain the respect of workers through their recognizing that management is both fair and firm in its treatment?

Today, the enigma of the "missing man" in the metal mining industry equals, and frequently surpasses in objective importance, the problems of ore development, drilling, sampling, pumping, milling techniques, geophysical prospecting, or any one of a hundred highly technical subjects. Unfortunately, as engineers, we have confined our attentions, in the main, to the scientific phases of mineral technology, relegating our man power problems to the background. But what good has all our scientific study and preparation been if we can't get the ore mined, milled, or smelted? What has happened to our labor supply? Where is the good old miner who could timber, drill a round, lay track, or do any job underground? How long will it be before we recognize that an efficient working force is the most priceless asset of any operation?

Our entire background, as engineers, has developed within us an aspiration to some day make a technical contribution to our industry which will make ore exist where there was only waste before. In research activity we invariably judge and gauge our actions by past experience and past conditions. That is our way of reaching logical conclusions. Does this method apply to the human element? Can we judge the future by the past in this field?

unfavorable labor market exists

Of what possible good is an economic plan for producing from a new ore body when the cost figures are based upon a labor market available twenty years ago? That market is no longer here. We are forced to admit that we must compete with other industries for our labor and that we must strive to make these jobs in our industry competitive ones—jobs that men want and are willing to work at to hold.

Many of us wave magic wands, carry rabbit's feet, and perform all sorts of legerdemain hoping, in this

way, to find an easy answer to these questions of labor supply and labor efficiency. Others have looked back at the "good old days" and assured their fellows that when "wrinkles are in people's bellies" the problem will be solved. To the latter group, the obvious question is—who can buy your products when wrinkles are in bellies? And while all these easy panaceas are being sought the metal mining industry slowly dies because of a lack of man power for development, coupled with labor inefficiency which relegates more ore to waste. Both of these facts tend to discourage the investment of capital, and it is this lack of capital which is killing off the industry.

It is neither fair nor reasonable, on my part, to attempt to cure this disease without a diagnosis. Many of you remember, better than I, those conditions which existed in our early, favorable, labor market. The employes could be divided into two general groups: (1) those who had families and homes; and (2) those who lived in the bunk house.

The members of the first group had much in common; they were an older generation of Americans who had been raised in the mining camps and who had gotten jobs in the mines, married, and settled down. Since these men could be depended upon they usually had the more specialized jobs such as hoistmen, blacksmiths, pumpmen, clerks, and supervisors. The second and more colorful group were the "tramp miners" who were largely uneducated but skilled immigrants. They had been accustomed to the extreme hardships of the Old World and were comparatively happy to spend their free time in the saloons, bawdy houses, and isolated bunk houses which made up the mining camp. There were enough of these transients to keep their jobs highly competitive. By the late 1930's those who were still alive were, largely, too old for strenuous underground work.

The man who was replacing the "tramp miner" in the 1930's was a different man. He had, in many cases, been raised in the camps, but the vistas that had been opened to him by the automobile, schools, radio, and the newspaper were far different from those of his father. He was far less content with the mining town and its opportunities, but the existing depression and local acquaintances made a mining job far easier to get.

As war industries developed, high wages drew these men away from the mining camp. They found better housing, higher wages, and more congenial surroundings—all of which later conspired to keep them from returning home. Tom and Joe joined the armed forces and traveled extensively, married in another area, and saw manners of life which were definitely more appealing.

Tom and Joe have been replaced by a 1946 "model," who is a poor imitation of the real thing. He is a man unwanted by other industries, drifting from place to place, a cast-off who has been forced into mining as a last resort. He is neither skilled nor dependable. He has an aversion to work of any sort. This is our "tramp miner" of today—the man of 1920 and 1930 is gone!

Those few skilled miners who have stayed at the mines are completely independent since their jobs are no longer competitive. Many work only as hard and as often as they please. Despite his tenure of position and its comforts, this miner is not sold on mining, and, what is worse, is advising his children to seek work in other industries. This is not a pleasant picture, yet it is a true representation.

get good miners and keep them

Our problem of the missing man, therefore, resolves itself into two phases: (1) how to attract good men to the industry; and (2) how to keep them once they are on the pay roll.

In seeking the answer to this riddle of the missing man I have asked the advice and comments of younger leaders in this industry. Ninety-five per cent of those queried returned thoughtful answers to my questions. For fear someone may think that I am merely "parroting" their ideas I would like it known that I am in basic agreement with their observations.

There exists a remarkable unanimity of opinion as to the solution. All of them agree, basically, that management must feel differently and act differently toward its men. The leaders of the mining and metallurgical industries must re-evaluate the importance of the labor force in their organization. All agree that the solution will be immediately expensive, but it is pointed out that those employers who have introduced human understanding into their personnel policies are receiving the greatest return for their labor dollars in the long run. Let me offer you a few suggestions relative to this missing man.

The average man applying for work today has a better education and a greater knowledge of the world than did his father. This knowledge, plus ambition, discourages him from living in the average mining camp. He does not like the idea of living in a dingy, drafty old house and, what is equally significant, neither does his young wife. Yet these people are the kind of folks who are becoming increasingly important in the mine operations of today.

Existing housing at the average mining camp presents the most imposing of all obstacles to attracting labor. This point is generally agreed upon by those polled, but their thinking does not embrace the paternalistic attitudes evidenced by low rentals of company homes.

The existence of even a better-than-average job with its attendant taxes and living costs presents few opportunities to a couple to save any money. Saved money, apparently, still represents security to many despite the grandiose promises of bureaucratic demagogues who assure all the good things of life from "the womb to the tomb." The possibilities of making home owners of these employes is entirely within the realm of reasonable thinking.

good housing within reach

The thought is advanced that the operating company assist the worthy and interested employe in financing a home through established federal or local housing agencies. This means that this industry must aggressively demand that established mining areas be included within the scope of approved districts for FHA loans.

One major smelting concern, which operates in an FHA approved area, has made home owning easy by underwriting notes for the down payments of those employes who wish to own

their home. This is repaid over a three-year period at the end of which time the employee owns the equity in his home and may dispose of it or not as he pleases. In event he leaves company employ prior to his three years, the accumulated equity and the home reverts to the company as liquidated damages.

Too often the mining company feels that the town site should be located close to the mining operation. This opinion is largely a relic of the "horse and buggy days." Modern automobiles, busses, and highways make modern living in modern towns relatively simple and ease the housing problem of the mining operator. The town of Carlsbad, N. Mex., is an example. A large proportion of the employes of those mining organizations operating in the vicinity are homeowners and taxpaying citizens, enjoying the modern conveniences of home living as well as that of a balanced community life. A minimum amount of labor difficulty has been experienced in the area when compared with metal mining areas, and each operating company reports the existence of a waiting list from which to hire new men in each classification.

This Carlsbad example is one which few organizations can expect to duplicate because the men originally built their homes there and largely were residents of the area. The precedence established by the older employes was followed by new men as the advantages of home ownership became apparent. Perhaps a new venture might require some underwriting by the operating company, but over-all improvements anticipated in labor relationships and the efficiencies incident to trained men overcome many objectionable aspects. The community becomes aware that a healthy, vigorous industry is necessary to its well being, and the home owning employe develops within himself a wholesome personal interest in the success of the operation.

At some splendidly planned camps, the houses are company owned and rented at nominal costs to employes. We all appreciate that in many of these situations all is not "joy and light." The employer has invariably found that such rental programs are highly unsatisfactory due to unsatisfactory tenants and many "landlord" complexities. It is appreciated that a certain number of persons will always prefer to rent rather than own.

In many instances isolation makes home ownership out of the question. What has been done in such instances to make community citizens out of employes? The Bradley Mining Co. at Stibnite, Idaho, is certainly an outstanding example of this type of operation. Its isolated character precludes the possibility of employe home ownership and as a consequence the buildings are all company owned. Houses are assigned to employes on a seniority basis by the Employes' Representative Committee which is elected by the employes themselves. This Company points out that it is not interested in making a profit from the rent of the homes, but is interested only in proper maintenance and as a consequence places the nominal rent paid into a "maintenance fund." No further "rents" are paid when this fund reaches a certain point. Contrary to many other housing programs, when the plumbing needs fixing the occupant hires the plumber; when the lights go out the occupant hires the electrician; and when the occupant leaves, the maintenance fund puts the house into the same condition it was when the employe moved in.

Stibnite has been established as a village under the laws of the State of Idaho. The bona fide electors of the village elect the Village Board of Trustees, who in turn appoint the treasurer, clerk, chief of police, fire chief, and police judge. A modern elementary school is maintained by the school district whose board is elected by the qualified voters. Here the employe lives near the mine yet has all the responsibilities and advantages of a citizen.

Substantial segments of your worker population need and demand comprehensive modern medical, religious, and educational facilities. A discouraged doctor and a mediocre hospital are poor inducements to a prospective employe to raise a family and settle down. Many operations which have splendid medical facilities do not accept the families of workers but refer such cases to nearby towns. One is hardly inspired to bring a pregnant wife into a camp knowing that on some "midnight clear" one may have to drive fifty miles over slick roads to beat the stork.

Few of us can stand and sing the praises of the schools and churches in our mining communities. What criteria have some members of our industry used in determining that a sound education, from a religious or academic standpoint, is not vital to their people? The kind of people you need in your operation have an impelling desire for such facilities and need not, today, accept less than the best.

Tom and Joe may be missing from your pay roll because there is nothing for them to do during their off hours. There do exist, in most metal mining areas, exceptional recreational possibilities. Certainly the isolated nature of many camps and the great outdoors offers exceptional opportunities. The mining operation and its citizens, as substantial taxpayers, should demand that the streams in the area be well stocked; that wild fowl and game availability be maintained; that snow sport facilities be fully developed; and that the access roads be comparable to other county projects.

For those who are not interested in outdoor sports a community center should be available. It should be operated for the employe by the employe. What good is a card room if poker playing is discouraged? If your employes want soft drinks or beer why shouldn't they be easily available? Why shouldn't a liquor store be operated? Why wouldn't a trained social worker be of inestimable value to your employe program as well as helping the miner's wife in planning economical meals, sewing, and similar projects? Too often the boss' standards, or those of his wife, become the standards of recreation and propriety — not infrequently do their standards diverge from those of the people who must be served—the employes.

Just how important a factor your wages are in tempting the "missing man" is open to question. Some rate it the number one problem; others relegate it far down the list by pointing out that they operate short handed despite the fact that their take home pay exceeds that of other industries in the area. Normally, however, we

find that our wage rates are comparable to other industries but hardly competitive. Thirty years ago this was not true; this industry enjoyed the distinction of being the highest paid. I question whether any individual can give the immediate answer to this problem of wages and incentive pay. Our industry, more or less, pioneered contract pay for specific tasks, but our thinking has not proceeded, in most cases, beyond individual incentives for individual jobs. It appears to me that the subject of equitable incentives for all employes within an operation would be a worthy study for a committee of the Institute.

more than money

It is so natural that in a world torn by chaos, cold war, and displaced persons that we be security conscious. Some seek this through their own savings; others feel that the attainment of security lies outside their, or our, demonstrated abilities.

Financial security, as contemplated by retirement plans, pensions, sick benefits, is not the only type of security our psychological makeup demands. Longfellow sang the praises of the village smithy, but who publicly sings the praises of check number 489 who runs a mucking machine on the 1500 level? How long has it been since you heard a miner brag about the round he pulled? Where management has neglected these security items in their contracts your employe seeks them through force. His government or his union promises them and you in turn pay the bill once the promise is consummated. All any man has to sell are his services, and a portion of his reward should be a supplement to that which we provide by a devious federal route.

why silence?

The existence, and public knowledge, of an effective accident prevention program has proven, time and again, the stimulus necessary to bring the missing man out of hiding. Our surveys in farming areas in Utah disclose that the rural population has an impression that almost every man who works underground is eventually maimed or killed by accident or suffers from a chronic lung disease. That we permit such a misconception of our industry to exist is a condemnation of our attitude toward the public.

The vast majority of our mines and smelters work hard to prevent accidents. Why do we exhibit such an inane reticence to publicize our good work? But we do just that. The community hears only the bad side of the news. Stories, carelessly repeated, of minor accidents grow to major catastrophes until the prospective employe is discouraged from seeking a job with you by his family and his friends.

Have you ever seen moths flit around an unlighted lamp? Chances are that it was a rare occurrence if you did! We can do all of these things that we have mentioned but unless men know about them our Tom and Joe will still be on the missing list. As an industry we have exhibited a public reticence and false modesty that has been, in my opinion, most unwise. What does the public know about your operation? What does the community know about your economic contribution to its welfare? What does your employe know about your little segment of the free enterprise system? What does the average American citizen care if every mine in America closes down? What have we done to sell mining, and its allied industries, to the American people?

I condemn the industry, as a whole, for its unrealistic attitude in informing the public and its employes. I must, necessarily, condemn the Bureau of Mines for following the industry's leadership and failing to apprise Americans as to what this basic industry means to America's future. I am firmly convinced that herein lies the most colossal sin of which we have been guilty.

I wish to commend the long range advertising plan being undertaken by the Joy Mfg. Co. A substantial portion of their advertising budget is being spent in an effort to correct some of these misconceptions about our industry among high school students. This Company recognizes the fact that within this group lies a wealth of potential users of its equipment, if they can be induced to enter mining as a career. It is recognized that if mines are unmanned their machinery cannot be sold. Other manufacturers and their representatives should realistically pursue a like course.

Every mining man and every group of mining men should do his part toward encouraging a better understanding of the economic factors affecting the industry as well as building up the contribution being made by it to the safety and well-being of our nation and our communities. This means that you must sell your little island of free enterprise to your community and to your employes. No association to which you subscribe can do this job—it is yours. This means work and a genuine desire to have people understand. Every civic club is seeking speakers; each convention wants to visit plants of interest; every legislator wants to see a mine or smelter and know more about it. Why not provide them an opportunity to understand our industry better?

Copper-Lead-Zinc Operations Revived

A new selective flotation plant was opened in Siskiyou County, Calif., as 1948 came to a close. The plant, built by the Coronado Copper and Zinc Co., treats 100 tons a day of copper-lead-zinc ores, from the old Afterthought mine at Ingot. These complex ores were unprofitable to work 25 years ago, when the Afterthought mine was shut down. Since then, however, methods, machines, and reagents have been developed in the selective flotation process and can now satisfactorily separate the zinc, copper, and lead minerals in the ores.

Copper Movie Available

A new 16 mm Kodachrome sound film called "Copper," which traces production of the metal from mine headframe to consumer, is now available to interested student and professional groups. It was filmed by the Anaconda Copper Mining Co. on the "richest hill on earth" at Butte, and can be borrowed without charge from the Company's advertising department, Rm. 2148, 25 Broadway, New York City.

New Ideas Rife at Cleveland-Cliffs

By JOHN V. BEALL •
MANAGING EDITOR

Hydro-Mucker reduces clean-up time in shaft by 40%.

Cutting costs and increasing safety with new ideas is the byword with The Cleveland-Cliffs Iron Co. on the Marquette Range in Michigan. Among the new ideas being tried out are mechanical shaft mucking, prefabricated lagging to replace timber poles, Carset bits in shaft sinking, and rubber tired guide wheels on the ore skips. Plans are being made to stockpile ore with conveyor belts during the winter.

In sinking the Mather "B" Shaft a ⅜-yd clamshell-type bucket is used for mucking. The clamshell is opened and closed by means of a vertically-mounted hydraulic ram actuated by 5000 psi oil pressure. An Ingersoll-Rand-type hoist is used to raise and lower the clamshell. The hoist is controlled by one member of the crew on the floor of the shaft. When the bucket is raised, the men swing it over the muck pile to the desired position and then it is lowered on to the broken rock. The 1400-lb weight of the bucket causes it to sink into the broken rock and it digs as the ram closes the bucket. The hydraulic ram is operated by a man on the lowest shaft steel set who controls a specially designed oil pump which supplies oil pressure. The clamshell is emptied into a 2-yd tray which, when full, is lifted for dumping by the same hoist that lifts the clamshell. A mine car is lowered to the bottom of the shaft on the cage and the tray is dumped into it. As the tray is lifted, the crew swings it into position so that two clasps on the lip of the tray grasp a bar on the side of the cage providing the fulcrum for correctly dumping the broken rock into the car. The speed of shoveling is dependent on the speed of the cage trip to and from the dump at the collar of the shaft. Less energy is expended by the mucking crew using the clamshell and the time required to clean up is reduced by 35 to 40 per cent.

The bucket was designed with the co-operation of the Milwaukee Hydrocrane Co., by J. S. Westwater, superintendent, and R. G. Schaal, assistant chief mechanical engineer, and is called the Hydro-Mucker. The company is in the process of perfecting a twin-ram clamshell which is expected to be even better. The pistons will be mounted at 45 degree angles, thus securing good digging action and quick opening.

Carset bits have become standard practice for drilling in the Mather "B" Shaft. It is possible to drill a round in half the time formerly required with ordinary detachable bits.

The first thing an Arizona miner would notice on visiting a mine in the Iron Country is the tunnels which lead from the change house and the shops to the collar of the shaft. These keep men and materials from being exposed to the subzero winter weather. At the Mather "B" shaft, concrete double-deck tunnels are being constructed from the dry and work shops. One tunnel will extend along the timber-storage piles and will have sliding doors on one side so that timber may be conveniently handled.

The new 13 by 18½-ft shaft is divided into two skip compartments, a cage compartment, and a manway and utility compartment. It is completely concreted to the 75-ft mark and is concreted at least every other set from there to the bottom. Steel shaft sets are on 7-ft centers and 14-gauge corrugated, galvanized iron is used for enclosing the shaft. The shaft, now down 2050 ft, is to be sunk to the 3100 ft level.

An experiment is being conducted in the use of rubber tires to ride on the shaft guides of the 12-ton skips used in the Mather "A" shaft. In this shaft, 80-lb rails are used for guides and the metal shoes formerly used on the skips experienced considerable wear from rope twist. Pneumatic tires and solid-rubber tires have been used as replacements but the solid rubber roller-bearing-mounted wheel is receiving favorable attention at this shaft, which produced more than 1,000,000 tons in 1948.

An electric eye is used at the air doors on the haulage ways to operate signal lights to warn people on the

other side of the door when a train is coming through. A 25-hp air hoist is mounted on a flatcar to be used in hoisting heavy equipment up raises. A slow speed air motor gives adequate control. The new Joy Hydrojib jumbo with an 8-ft chain feed is being tried out for drifting.

Another interesting experiment is being conducted in the use of concrete slabs for lagging between steel sets on main levels. These slabs are reinforced by steel rods and are 2 in. by 8 in. by 6 ft in size and can withstand a 1500 lb load on a 5-ft span. They are being used to replace 4-in. wood poles which had formerly been used for overhead lagging on the main levels. The permanency of the concrete slabs is of course a factor in determining their economic value, but the chief reason for their use is the fire-proofing of main ventilation and haulage ways in conjunction with the use of permanent steel sets.

A new pumping station will be put into operation shortly on the sixth level. Three Worthington 500 gpm twin compound double-acting reciprocating pumps with 4⅞-in. diameter pistons with 18-in. stroke will be driven by 350 hp G.E. synchronous motors. Two sump drifts 215-ft long with a cross section 10 by 15 ft will be used for water storage. Permanent slusher slides have been installed in the sumps to facilitate cleaning.

Shift bosses are selected after close observation of prospective candidates by the supervisory personnel and after the candidates have worked at all the jobs in the mine. Bosses are trained in Brunton surveying, geology, and mapping, and this consequently lightens the task of the engineering staff.

It is planned to use belt conveyors for stock-piling ore at the Mather "B" shaft when it goes into operation. Winter conditions on the Lakes make it impossible to ship iron ore more than eight months out of the year and therefore stock piling is common practice at all of the iron mines in the Lake Superior district. This is normally performed by stock-piling cars operating along a trestle and dumping the ore at various points alongside. It is felt that by utilizing enclosed conveyor belts it will be possible to reduce the costs of handling ore for stock piling. One of the problems encountered is that the rigorous weather conditions may cause particles of ore to freeze to the belt. This problem has been successfully handled at Tahawus, N. Y., by heating the galleries in which the conveyors move. Grover Holt, chief engineer of The Cleveland-Cliffs Iron Co., who has studied methods of heating belt conveyors, thinks that steam heating plus individual electric heating elements will be sufficient to prevent the ore from freezing to the belt. A modest start will be made with a 650-ft belt to determine the results which can be achieved before constructing the complete stock piling setup. It is estimated that 750,000 tons can be stock-piled this way and that the first conveyor will be in operation in a year.

Underground at the company's Athens mine is an interesting comparison of electrically controlled traveling feeder and belt conveyor versus conventional 60-in. scraper in separate transfer drifts under a block cave, furnishing at present about one half the mine's 2300 ton daily production. The feeder straddles the belt and is spotted under the chutes along the belt transfer by the tappers working on the grizzly sublevel above. When reasonably free running ore is encountered, as is the case at times, the feeder and belt system might well be termed "push button mining."

The jet piercing process, utilizing a petroleum-base fuel and oxygen in a special blowpipe to drill holes in rock, was tested on the iron formation and showed favorable results. Experiments were conducted with two 9-in. churn drill bits, using tungsten carbide inserts. Additional work must be done to ascertain the economic value of these larger diameter hard-tipped bits.

The geological department, under the directorship of E. L. Derby, Jr., is making history in drilling techniques. So far as is known, they are putting down the deepest holes yet drilled in iron formation, one having passed the 4100-ft mark. Several other holes have also exceeded depths previously drilled in iron formation. In the course of the recent drilling campaign, some of the underground workings have encountered older drill holes and, after the former had been surveyed and plotted on maps and cross sections, it was found that the surveyed position of the holes checked the original locations within 10 to 15 ft; incidentally, the Maas compass was developed at Cleveland-Cliffs. This is a fine commentary on the accuracy of drill-hole surveying. Black diamonds are used in diamond drill bits to depths of 2000 ft or more; a change from black diamond bits to Bortz bits being made when the risk of losing the bit from depth or difficult drilling conditions becomes excessive. Black diamonds have not increased in cost as much as Bortz and since Cleveland-Cliffs still has a crew of craftsmen to set the diamonds, they are more economical than Bortz bits. The drilling machine utilized for the deep holes is a No. 4 Longyear two-speed 40-hp hydraulic drill. Drills are run on 125-lb steam pressure generated in coal fired horizontal boilers.

Concrete tunnels at the Mather "B" shaft will protect workers from frigid weather.

Annual Meeting Reports

Banquet comes but once a year, and the Garden Court at San Francisco's Palace Hotel was well-filled with celebrants for this, the high spot of the 1949 Annual Meeting.

New Methods Disclosed at Mining Sessions

REPORTED BY LOUIS H. McGUIRE AND JOHN V. BEALL

Between the California sunshine and San Francisco's robust night life, the miners were well satisfied to leave their snow bound diggin's for a week's sojourn in that fair city. Attendance at technical sessions struck lows of 50 and peaks of 200. This attendance record did not cut in on social activities and vice-versa. No particular credit is claimed for this feat because, had it been otherwise, we would have blushed for the profession. There were many new faces at the meeting not seen in New York in previous years so it is to be hoped that there will be more meetings around the country.

On Monday morning the vital subject of health and safety was discussed in three papers covering the new developments in mining safety, metal mine dust control, and safety practice at the Combined Metals Reduction Company's mine at Pioche. Progress in safety was evident from the downward trend of severity rate statistics collected by the Bureau of Mines. Concluding remarks by Chairmen Ash and Borcherdt pointed up the fact that a practical safety program rigorously pursued by management and labor, working as a team, can do much to reduce accident rates. One aspect of this meeting which was extremely practical was the fact that those in attendance were not exposed to the hazards of the registration melee in progress in the lobby of the Fairmont or the physical exertion and mental strain required to assist the wife in unpacking bags.

gold starts program

In tribute to California's Gold Centennial, the first paper on the Mining Methods agenda recounted the history of California gold mining. Maximum production was achieved in the years 1853 and 1854 and ranged between 62½ and 69½ million dollars annual production, mostly from placer gold. Gold production for California in 1948 is estimated at 14½ million dollars which puts it in ninth place in dollar volume as compared to other mineral products. Herb Sawin concluded that, although the number of men working placer deposits during the depression of the thirties approached the numbers thus engaged during 1848 and 1849, the returns were pitifully small. California's

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placer gold has, through the years, added to the nation's wealth and now rests in the form of gold bullion in the nation's treasury. This is sad news to the many miners present who planned to spend their declining years leisurely panning gold and spending the returns in San Francisco looking at the mermaid in the gold fish bowl at the 365 Club.

In describing alluvial tin mining in Malaya, A. D. Hughes said that production had returned to about two thirds of the prewar average yearly production. Known reserves of unworked gravel amount to three or four billion cubic yards but if the price of tin remains at its present high (99¼¢ in 1948) marginal areas may become economic, adding to the reserves. Unless there is another war, supply will equal demand at some future date and this date depends largely on United States stockpile demands.

The iron mining industry got in its licks in two papers and a movie. Stripping operations at the South Agnew were shown in a color movie and were most interesting in spite of the fact that a weak light in the projector made some parts difficult to see. Weak projector lights, upside down slides, missing projector operators, searches for the light switch, and similar troubles go with any good technical session and the real miner isn't even annoyed by these inconveniences. Mining practice in the open-pit mines of Minnesota was described in an interesting paper by John Hearding. In producing 181 million tons of shipping grade ore in the last three years, it was necessary to handle 600 million tons of material, or 3½ tons of total material handled for each ton of shipping product produced. Having dropped this teaser we'll leave you to read John's paper when it appears in *Mining Transactions.*

Jim Westwater described the new Hydro-Mucker being used to sink the Mather "B" shaft of Cleveland-Cliffs. It is a clamshell bucket which is opened and closed by means of a hydraulic ram. Rate of advance has increased by an average of 22 ft per month for the four months that this mucker has been in use.

tungsten-carbide makes good

The much-written-about Holden mine of the Howe Sound Co., which pioneered in diamond-drill blasthole stoping, again came into the limelight in a paper presented by Elton Youngberg on the use of tungsten-carbide bits with percussion drills for drilling blastholes. This new method will, for the most part, be used instead of the old diamond-drill method. This excellent paper is published in the March *Mining Engineering.* Donald M. Davidson presented Royce's paper on the analysis of drill core and sludge samples. It provided a mathematical formula for the percentage of sludge to be applied when complete core is not recovered. This seemed to be Don's day for he was also asked to read Lee Armstrong's paper which described the difficulties which Longyear had encountered in drilling quartz-feldspar intergrowths. The degree of penetration was low, and the diamonds were polished after a short period of drilling. A. E. Ross, of Scranton, Pa., volunteered the information that his company had had greater success with this type of drilling by using more and smaller carat diamonds in their bits.

All our problems will be solved when we get a copy of Professor Riddell's paper on the risk factor in mine evaluation. This controversial subject was presented by Jim Fisher in Riddell's absence—the substitute team really was in there pitching. R. D. Parks commented that evaluation should be viewed as a forward look at a mining property and that engineering methods should be used to set limits in less clearly defined properties. Jim asked Parks how he would vary the fomula if he was buying or selling the property. This seemed like a happy thought but Mr. Parks replied that he wouldn't. Continuing on the subject of drilling and sampling, Leon Dupuy outlined a drilling campaign which attempted to recover core for metallurgical tests from unconsolidated material. It seems that this campaign disclosed much useful drilling information, and also served as a character building course for all concerned. After trying churn drills, diamond drills, and several types of bucket drills to attain the objective the boys had all developed the patience of Job. Leon delivered his paper in a droll and, what would be termed in political circles, "off the cuff" speech which modestly minimized the accomplishments and accentuated the difficulties.

new mining practices

A visit to Copper Canyon would be a good idea for those interested in seeing a different way of mining steeply dipping veins on relatively small scale operation. Sublevel stoping is used but the benches are cut in reverse steps to normal procedure. Draw points are finger raises from short crosscuts driven off the main haulageway at right angles. The ore is loaded by mucking machines which dump ore into the sides of cars pulled by on the haulageway. The following advantages are claimed: (1) high safety factor; (2) benches don't have to stand long; (3) direct access to stopes; (4) good ventilation; (5) lost drilling time minimized; (6) several levels can be drilled at the same time; (7) all drilling is for slab rounds so less skilled miners are needed; (8) gravity helps fragmentation; (9) ore pulled as fast as broken; (10) low supply and supervisory costs. Since Jim Westwater was present from the Iron Country, where they write the book on sublevel stoping, his comments were requested. He admitted that a slusher setup was not as flexible for a small operation, that more development work was necessary which tied up a big block of ore in pillars, and that the mucking machine setup at Lillie's operation looked good to him.

From Charles Lambly's account of what is going on in the Metaline district it appears that they will have a lot of material for publication. The new incline being sunk will be equipped with a conveyor for hoisting ore. A new method of stoping to be called contour stoping will be used, as will tractor locomotives. Under the new set up, 300 tons per hr can be hoisted by two men, and supplying men with materials is expected to be achieved at lower cost. Since

Jim Richardson wasn't present, probably entombed by severance tax legislation rather than snow, his paper, based on a secret questionnaire he sent to mine operators, was read by Ray Sumner. A study of the solutions to the mine labor shortage, it's called "The Mystery of the Missing Man," and you can read it in this issue. Guy Bjorge said that he thought the article was a severe condemnation of the industry. He went on to describe the conditions at Homestake where the picture isn't as gloomy as painted in Jim's article. Mr. Carter, a student from the University of California, commented that the industry needed a little publicity on the high school level. Henry Carlisle presided at this session and did a swell job keeping things moving along.

Western phosphate described

At every meeting one's rear end begins to get numb and, in this case, many felt that a hotel with the reputation of the Fairmont could have done better with padding for the chairs. Only the memory of the previous night's smoker sustained us. The subject for discussion was phosphate mining in Idaho, Wyoming, Montana, and Utah. E. M. Norris introduced it, and presided, also reading several of the papers in the absence of the authors. The western phosphate field covers portions of the four states mentioned and, as indicated in the first paper on the geology of the field, the structure is more complicated in the western side of the field and the phosphate content increases to the west. The Bear River region has the richest Idaho deposits with about 350 million tons of minable reserves, a million of which contain more than thirty percent P_2O_5. The USGS objective in this area is to ascertain the quantities and varieties of minor elements, such as vanadium, present in these deposits. Conda, Idaho, operations of Anaconda were described. The beds dip from 50 to 60 degrees and the ore is blocked out by driving three-compartment raises on 100-ft centers and sublevels on 30-ft centers. The ore is drilled with 6-ft auger steel and broken ore slushed to the chute compartment of the raise. The mine is worked six days per week and about 590 tons are produced a day. Concentrates are recovered by a simple washing process. Thirty tons per hour pass through the scouring mill to the classifier; the sand goes to a rotary dryer, wedge-type roaster, and rolling mill. Expanded operations are in the offing.

SAMPLE COST FIGURES ON PHOSPHATE STRIPPING OPERATIONS

Stripping, $0.10 to .18 per cu yd
Diamond drilling and enginetering, $0.20 to 0.30 per ton ore developed
Stripping shales, $0.25 to 0.40 per cu yd
Stripping cap rock, $0.40 to 0.75 per cu yd
Mining phosphate rock, $0.20 to 0.35 per ton
Depreciation, $0.25 to 0.50 per ton
Depletion, $0.10 to 0.40 per ton
General expenses and tax, $0.40 to 0.80 per ton

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At the Waterloo Hills operation in Idaho, phosphate is mined by open pit methods and stripping is done by scrapers pulled by tractors. Push cats are used to load the scrapers. About 650,000 tons of ore have been mined. At Beckwith Hills, the cap rock has always added to the difficulty in stripping. The cost of handling overburden is between 23 and 25 cents per yd. Norris supplied some general cost figures on stripping operation.

Fort Hall, Idaho, has the unique distinction of being a mine partly owned by Shoshone Indians who receive royalties. A systematic drill campaign with diamond drills on a 150-ft grid was conducted. Holes were reamed and cased to the bottom. In order to obtain good core recovery, short drill runs were used, water was carefully controlled, and a bonus based on core recovery was given. A three year time study was conducted to determine the best equipment for the stripping job. The ¾-yd shovels were determined best for loading phosphate because they could be used selectively, thus avoiding picking up waste. Extensive sampling is done to permit selective mining. Strict control of the mined product must be maintained because a minimum of 31 percent P_2O_5 content ore is necessary for electric furnace charge. Low-grade rock is set aside and only some of the Idaho rock is amenable to screen separation. It sounds like a well thought out and organized operation. The Indians ought to do well.

The unpadded chairs should have been used for gob. J. B. Haffner made his entrance as substitute chairman for George Dub, but we were so attentive to our derrière that we didn't note the change. In Mr. Armstrong's absence, Norris again took the rostrum to describe underground phosphate mining operations at Garrison and Avon, Mont. We were beginning to think that Idaho had a corner on the minable phosphate. Access to the Anderson mine is gained through a tunnel or by a 475-ft shaft. Two levels were developed by drifting in the quartzite footwall with conventional rock drills making an 8 by 8-ft cross section. The flat-dipping beds are mined by open stope room-and-pillar method. Entrance to the stopes is gained through chutes to which the rock is slushed. Flexibility in scraper operation is achieved by using an adjustable steel stull to carry the tail block. It has been found that 300 ft is the economic slushing distance so that the levels are set this distance apart along the dip.

In contrast to the attitude of the Anderson mine beds, the phosphate beds of the Gravely mine range from 65 degrees to vertical in dip. Three compartment raises on 50-ft centers are used from which shrink stopes were at first tried. However, since the ore packed too tight for free drawing, it was slushed to the raise chutes after mining the block. This has proved expensive in timber. Monthly production is about 5000 tons.

At the Mining Methods Committee luncheon an interesting and informative film was shown by Jim Kemp on the old Cornish pumps in England. These pumps were developed in Cornwall because of the necessity of economizing on fuel which was expensive because it had to be shipped from other parts of England. Jim was stationed in England during the war and visited Cornwall, where he saw the pumps and decided that the Shell Oil Co. films tracing their development would be of interest to AIME members. He'll circulate the films to interested groups.

Not a woman in the house. The Stag-Smoker at the Commercial Club was a big success.

mine and plant safety

Safety practices at the Crestmore mine of the Riverside Cement Co. are administered by a mine safety committee composed of employes and supervisors. They meet once a month and any suggestions must be carried out within thirty days. A separate housekeeping committee makes inspections to see that mine and surface plant are kept clean. There is a monthly bonus for the safest crew, and the boss with the best safety record receives a bonus at the end of the year. Mention was made of a wooden guard over the trolley at draw points, which seems like a pregnant idea considering the frequency with which chute pullers get a charge. Westwater wanted to know if the safety bonus worked. "As a matter of fact," Randall Wightman replied, "it does. Though the money doesn't amount to much it will still buy a few beers the wife doesn't know about." Ed Borcherdt briefed Gerald Sherman's paper on block-caving operations in asbestos in Quebec. Steel sets are used throughout as no wood is allowed underground. Back filling is done from the surface. Surface subsidence occurs, leaving vertical banks. In reply to a question by Franz as to the ventilation, Ed said that it was good underground but that milling operations spread lots of dust over the countryside. The company is studying means to prevent this nuisance. Bob Thomas gave a most interesting account of block-caving at Ray, Ariz., where shaker conveyors are used to collect from the draw points. Drawing is at a rate of about a foot in 8 hours which yields them about 200 tons per man-shift. Michelson spoke extemporaneously on the caving operations at Braden in Chile. Weed said they were drawing 5 ft a day at Inspiration. Still, of Miami, commented that they rarely got a perfect stope, but this is common to most block-caving operations.

mechanization speeds operations

Carroll Weed read Bain's paper which mentioned that jumbos had increased production rates from 54 to 93 tons per man-shift. At St. Joe they had been successful in standardizing a drill round using the jumbo as a template. Charlie Lambly put in his oar to say that at Pend Oreille, in a 6½ by 7-ft drift, they had pulled as much as 13 ft but averaged 9 ft per round. It takes four man-shifts to make a round. Care is exercised to keep holes parallel and they are loaded to 1½ ft from the collar. Franz said that the fastest drilling he had seen was with two men; one drilling with two machines and the other knocking off bits and swamping. Watch that swamping! Haffner was substitute chairman for Walker and really kept the ball rolling. E. D. Gardner, who was trying to sell tickets to the Thursday morning session at which his paper on oil shale mining was scheduled, commented that they did it better at Rifle. Roy Hooper, of Bunker Hill, described their jumbo setup and the mucking device for sinking the incline used up there. It is a combination bucket and slusher scraper and enables them to complete a cycle in 6½ hr. J. C. Landenberger read Pett's paper on developments in mining practice at the Utah Copper pit. This was a meaty paper that you will have to wait for in *Transactions*.

Sipprelle described the advances in mining technique at Rifle. Jumbos are used to drill a 60 by 27-ft face with 10½-ft holes. Longer sashes on the drills and hard-surfaced bits are used to drill an entire hole with one steel. These innovations have reduced drilling time from 27 man-shifts to two. Diesels are used underground without creating a harmful concentration of fumes. At present studies are being made on aldehyde removal by a catalyst and on a scrubber. Floodlights are mounted on all heavy equipment to improve working efficiency. Air and water lines have been eliminated by mounting a compressor and water tank on trucks which are taken to the working face. Mr. Gardner said that there will be a public test demonstration of all equipment next September. Mining costs at Rifle are $0.497 per ton to produce 81 tons per man-shift underground or 56 tons per man-shift total labor.

An interesting description of dump leaching at Chino was given by W. H. Goodrich in the absence of the author, A. F. Morris. Goodrich said that their leaching operation had been so successful on what had formerly been considered a waste dump that he advised any copper mining company to be sure to put dump or strip material where it could be successfully leached should it become economically and technologically feasible to do so. He also advised care in keeping waste dumps classified as waste, lest the government become anxious to include it in mine reserves. At Chino the dumps are on impervious ground so that they get the leach liquor back without difficulty, but this is a matter of fortune rather than planning.

Ponds are allowed to dry and are releached later. This has been in progress for nine years there. The dump averages about nine pounds of copper per ton.

John Hall wound up the mining sessions with a paper on pumping at the Chief Consolidated at Eureka, Utah. Pumping at Eureka is unique in that the water pumped is discharged into natural underground caves. This has resulted in tremendous savings in equipment as the static head has been reduced from the 2735 ft necessary to reach the surface to 935 ft. Without this cave it is questionable if ore below the water table could be mined economically. Herein lies a mystery. What happens to the water in the cave that keeps it from returning to the mine? Yes, they are sure it does not come back. Volumes up to 4000 gpm have been disposed of in this manner.

MBD Has Comprehensive Program; Maps Plans for Coming Year

REPORTED BY E. H. ROSE

The San Francisco meeting marked the completion of the first full year of functioning of the mineral dressing group as a Division of the Institute. The vigor of the business meeting on Sunday preceding the technical sessions, the teamwork planning of the various committee chairmen for this meeting and those to follow, the smooth and steady inflow of program material, and even the healthy state of the treasury amply attest the wisdom of breaking away from the old milling methods equivalent of the one-man band with foot-operated trombone.

Appropriately, the technical sessions started off Monday morning with MBD and the Coal Division teaming up to consider western coal washing practice. Industrialization of the far West and wartime establishment of blast furnaces, where none had been before, have set up unprecedented demands on the western coal industry. Preparation methods practiced are jigging, dry air separation, and heavy-media separation, with the first-named now predominating. The washability curves show western coals to be "difficult." It was said that plant costs which were about $1000 per ton per hour in 1939 rose to $2000 in 1942, and are of the order of $4000 at present.

Expected bloodletting failed to materialize at the Monday afternoon session on grinding where eight papers were listed. The old controversy of grate versus overflow mills has largely simmered down to agreement on overflow type for the fine end of the grinding range and grates for the coarser,

Well-fed members of the Minerals Beneficiation Division were glad they attended their luncheon at San Francisco's Hotel Clift.

while that on mill speed similarly rationalized on attractive increases in capacity (and capital utilization) with speed up to a critical limit, with minor loss of mechanical efficiency but proportional increase in per ton steel consumption. A manufacturer-operator bout which developed consisted mostly of defensive sparring. For those who like a cork screw and a built-in jigger on their bottle opener, an oddity turned up at this session in the form of a scheme for simultaneous grinding and flotation, and of this more again next year, we hope.

Tuesday morning's session on flotation operation comprised an eminently practical consideration of plant examples. A number of Arizona faces brightened up when DeWitt, of Michigan State, came up with something more than the germ of an idea for floating copper silicates. Even the afternoon session on flotation theory had its practical moments, somewhat to the surprise of die-hard skeptics. The utilization of heat and time to obtain chemisorption as opposed to physical adsorption of oleic acid on fluorite opens up an interesting mode of attack on other flotation problems. Emphasis on the utilization of heat in connection with flotation—an important variable deserving more attention than it has received—tied in well with the morning session on flotation practice, where the use of heat for Cu-Mo, Pb-Zn, and Cu-Ni separations had been discussed; not to mention the survey being made in Arizona on the effect of grinding circuit temperature on the depression of pyrite. Many failed to

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be convinced, however, that the theory proposed fitted the facts.

Concurrently, a session on pyrolysis and agglomeration was well attended despite the counter attraction of flotation theory. A splendid account of a laboratory study of the problems of sintering fine materials was ably presented by Mead, of National Lead, and evoked much discussion. The trend to finer mill products in the nonsulphide field being what it is, especially as regards the iron-ore industry, spot accounts of progress in agglomeration on the various experimental fronts given at this time were especially valuable. On the basis of present experience, it was predicted that Pickands Mather's pelletizing operation on the Range will become a commercial success. Good structure and good heat economy have been attained but movement of the charge down the furnace continues temperamental. Briquetting of fine materials is coming in for a play, especially as regards southern iron ores whose inherent clay facilitates such an operation.

Wednesday's sessions on hydrometallurgy likewise stuck largely to practical matters, beginning with a timely paper on extension of the use of activated charcoal in cyanide plants. Results of pilot-plant operation were reported, including modification of flotation technique and carbon container, and reactivation of the charcoal after desorption. Advantages propounded, as compared with conventional cyaniding, were low cyanide consumption, high extraction on a wide range of ore characteristics, and presumably lower capital and operating costs. In an academic interlude, the mathematics of countercurrent decantation was considered, using the number of thickeners and/or filters as the variables to show the effect on gold losses in tailing and on lime and cyanide consumption. Though at the disadvantage of substituting for the authors, Dr. Herz, of Rohm and Haas, ably gave a recap of ten years' development of ion exchange resins and a forecast of their future in mineral dressing, e.g., in the control of unwanted soluble salts in flotation, or actual capture of values in hydrometallurgical operations. Lack of selectivity so far has impeded their application to mine waters, but this is not necessarily the final word. The rise in importance of so-called rare elements, such as rhenium and hafnium, and others not mentioned by name, is a spur to ion-exchange research.

The afternoon session appropriately addressed itself to intra-process production of dilute sulphuric acid for the leaching of low-grade ores, especially those of manganese, a field in which further progress is eminently to be desired.

Joint session with IMD

Scheduled in another ring at the same time was a joint session with the Industrial Minerals Division, at which the Noralyn phosphate operation was unveiled. Those of us present who had had the good fortune to see this outstanding new plant could reassure those who hadn't that it is well worth the long trek to Florida to see, but Milt Le Baron's suite of descriptive papers on novel elements of practice there was a neat approximation of the real thing. The modern engineering approach to a problem of plant and metallurgical design, with the assistance of actual scale models of the buildings and equipment, and control of plant operation by a galaxy of recording instruments constitutes a landmark in the history of mineral dressing.

cleanup session

Thursday afternoon's "cleanup session" lived up to its name, in that some of the ashes of theory, the butts of incorrect data, and the burnt matches of experimental failures were swept up and dropped into the ash can after resifting for a possible fallen diamond or two. As should be the case at a cleanup session, numerous points came up for discussion for which there had been no place in the tightly scheduled procession of papers on preceding days. Little had been heard of the Driessen cyclone despite its prominence in the 1948 New York program, and some of us wanted to know why. This brought out a statement that the cyclone is being tried out as a deslimer on phosphate in place of hydroseparators. One investigator reported segregation of fine medium and the production of an excellent but unintended ferrosilicon concentrate. At any rate, the cyclone is still attracting plenty of investigation.

In the meantime, Fred Bond's Research Committee on Comminution had withdrawn to a secluded room to ponder new approaches to the arcane profundities of grinding, around which so many mill men have tramped for so long to so little avail. Although the Allis-Chalmers grindability tests have, through the years, become encyclopedic in their coverage of individual ores and have become increasingly precise, there is still no practical way of typing ores to permit generalizations. The most expedient thought seems to be a mass attack by all concerned by sheer weight of correlated data from operating plants. Such a procedure would cost money, but at least it is one of the possibilities that has not yet been tried on a comprehensive scale and even a small improvement in present-day grinding methods would pay handsomely. Though they did not express it that way, the committee thinks a pari-mutuel scheme might pull in a few bets on Frontal Assault to win over Comminution by at least a nose. The Sage of Copperhill, on the other hand, openly declared, at another time and place, that all existing information on grinding performance "is just a bear trap."

At various business and committee sessions, MBD plans for the coming year were crystallized and are already off to a running start. A symposium will be a feature of each Regional Meeting. That of the 1948 fall meeting at El Paso is being edited. For the Columbus meeting next September, the theme will be mill management, with a lead-off paper by Walter Maxson. At the next Annual Meeting, the grinding session will carry several papers on mill liners. An artist's sketch of the approved design for the new Richards Award in mineral dressing was shown. It is expected that the first presentation of this award will be made at the 1950 Annual Meeting.

Although strictly nontechnical, except for a Russian paper on research finesse presented in the trans-original by Donovich Wottamanoff Skotski (Don Scott to you), the MBD Luncheon on Tuesday bore eloquent testimony of the unified resolve of the group to meet any and all raw mate-

rials challenges. As a further challenge and inspiration to all of us johnny-come-latelies, several eminent oldtime pioneers of the mineral dressing profession were present and made brief talks. Dr. Dorr was able to speak of the beginnings of modern classifiers and thickeners, and Dr. Oliver told of the birth of continuous filters, both making it all sound too easy for the comfort of our present frustrations. Or were they spoofing?

Nonmetallics Group Invades the Gold Country

Three and a half days of continuous sessions at the Annual Meeting left Industrial Minerals Division members weary, but they smiled for the "birdie" during their Hotel Clift luncheon.

REPORTED BY HOWARD A. MEYERHOFF

At San Francisco, the Industrial Minerals Division displayed its willingness to step in where angels fear to tread. San Francisco has long been noted as a metal mining center, with special emphasis on gold; but in recent years Californians have become increasingly conscious of the fact that there is more than gold "in them thar hills." The fact is, there are several industries based upon nonmetallic raw materials that rival gold in value, if not in romance; and in a paper on "Roofing Granules of the Southwest," Stuart H. Ingram has revealed the unromantic fact that the value of raw materials utilized for this kind of roofing alone falls only $2,500,000 short of the total value of gold production in the United States.

The Division was in continuous session from Monday morning until Thursday noon, but even so, its program was so full as to require concurrent sessions Wednesday afternoon and Thursday morning. The ramifying interrelationships of Divisional interests were demonstrated by the number of joint sessions: on Wednesday morning the symposium on phosphate mining was sponsored jointly with the Mining Methods Committee; on Wednesday afternoon the program devoted to Noralyn phosphate operation was arranged in cooperation with the Minerals Beneficiation Division; and the Thursday morning programs on "Geology of Industrial Minerals" and "Titanium" were joint sessions with the Society of Economic Geologists and the Extractive Metallurgy and Iron and Steel Divisions, respectively. The number and variety of the joint technical sessions is an eloquent commentary, not only upon the interdependence of the several fields covered by the Institute and its affiliated societies, but also upon the frank recognition of this interdependence on the part of the Institute membership.

For the first time, the Division recognized water not merely as a necessary adjunct to mining, milling, and processing nonmetallic raw materials, but also as a resource in its own right. On the Monday morning program, George C. Tenney and R. G. Folsum discussed water and power resources in the Pacific Southwest, and Joseph F. Poland presented the sober facts of the ground water situation in California. Robert L. Wing gave his audience a clear picture of the problems related to the applications of this resource to the mining and manufacturing industries in California. If anyone had any doubts about the nip-and-tuck race between supply and demand, the doubt was reduced to statistical certainty by the authors of these three papers. Untapped sources of supply are severely limited, and the Pacific Southwest faces the need of further importation of water, possible use of the waters of the Pacific Ocean, or the extended utilization of other sources of energy

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to meet the projected demand for power. This program on resources did not entirely neglect mineral raw materials, though it came inadvertently close to doing so. William B. Mather presented a comprehensive survey of the nonmetallic resources of Arkansas, but Charles F. Deiss's paper on dolomite resources of the western states was crowded into the Tuesday afternoon session because of the failure of the management to supply projection equipment until 10:15 a. m., instead of at the posted starting time of 9:45 a. m. In fact, the chairmen of the several sessions were repeatedly handicapped by the failure of projection equipment and lantern operators to arrive at the meetings on time.

The growing interest of nonmetallic operators in problems of mineral economics was attested by the excellent attendance and animated discussion of the papers presented at the Monday afternoon technical session. Raymond B. Ladoo led off with a presentation of the ABC's of industrial mineral economics. Excellent papers by O. M. Wicken, Roscoe E. Bell (presented by Luther D. Hoffman), and Henry Mulryan developed the economic problems associated with specific industries. Although the list of papers was short, the sessions ran overtime in consequence of the discussion of specific and general problems. It was the consensus that the industry might profit by the development of standard specifications for mineral raw materials, and by closer co-operation between producers and consumers. In general, the producer likes to sell what he takes out of the ground with a minimum of processing, whereas the consumer prefers to continue operating with a familiar product, avoiding experimentation with new sources of supply that might give him a better result.

The importance of, and interest in structural raw materials were conclusively demonstrated by the attendance and number of papers in the sessions scheduled for Tuesday morning and afternoon. Ten of the papers in these crowded programs were devoted to problems and progress in the manufacture of cement and its use in concrete, and in the development of lightweight aggregates. Although attendance at the Divisional meetings was uniformly good, it reached a peak in these two sessions, and there was standing room only for certain of the papers, notably the one on "Fuel Economy in the Lepol Kiln" by Robert A. Kinzie. So far as the officers of the Division are aware, Mr. Kinzie was not confused with Dr. Kinsey, and the large audience was a genuine reflection of the importance of the announced subject.

Equal interest was displayed in the phosphate industry, and there were morning and afternoon sessions on this general subject on Wednesday. The morning symposium on phosphate mining was concerned entirely with operations in the phosphate deposits of Idaho, Montana, and Wyoming. In fact, the morning was not long enough for all of the papers on the subject, and one, by Frank R. Hunter, was carried over into the general session Wednesday afternoon. The joint session with the Minerals Beneficiation Division gave I. M. Le Baron an unparalleled opportunity to discuss the technical developments which have taken place in the Noralyn phosphate operation. Running concurrently with the latter program was a general session in which attention was divided almost equally between pigments and pegmatitic products.

The Division's concluding sessions were held Thursday morning. While the joint session with the Extractive Metallurgy and Iron and Steel Divisions provided a specialized program on titanium, the joint meeting with the Society of Economic Geologists gave the geological members of the Division a break. The latter program was varied, opening with a general paper on the use of aerial photography in the development of nonmetallic mineral deposits, by Richard M. Foose and Robert C. Stephenson, while the five remaining papers dealt with the geological aspects of specific mineral deposits.

Other features of the Division's activities included the Divisional Luncheon at the Cliff Hotel on Wednesday. The guest of honor was Edward H. Robie, who had just been elected Secretary of the Institute. Richard W. Smith, retiring Chairman of the Division, presided and introduced the incoming chairman, Howard A. Meyerhoff, who briefly outlined the Division's plans for 1949. He announced the Executive Committee's acceptance of a cordial invitation to hold the Fall Regional Meeting of the Division at Tampa, Fla., early in November, with field trips to the phosphate operations nearby. He also announced the expectation of a Northwest Conference on industrial minerals on May 14 at Spokane, together with the Sectional meetings devoted to industrial minerals in San Francisco and Los Angeles during the month of October. The Division also expects to sponsor a day of technical sessions at the AIME Regional Meeting in Columbus, Ohio, in September.

D. H. McLaughlin congratulating new AIME President L. E. Young (right), as A. A. Sproul awaits his turn, at the Annual Meeting.

Atomic Mineral Deposits Highlight Mining Geology Program

REPORTED BY M. R. KLEPPER

An unusually well balanced and informative group of papers was presented at four joint sessions of the Mining Geology Committee and the Society of Economic Geologists. A session on atomic mineral deposits highlighted and climaxed the program. In a paper read by Donald H. McLaughlin, John K. Gustafson, manager of raw materials operations of the Atomic Energy Commission, discussed the impact of atomic energy on economic geology. He outlined the current activities of government agencies, particularly the Atomic Energy Commission and the Geological Survey, in the search for and study of deposits of atomic raw materials, and pointed out that the function of the government geologist should be to obtain information necessary for the formulation of government policy. Beyond this point, private industry must accept its responsibility. It therefore behooves industry's geologists to know what rocks or minerals to look for and where they are most likely to be found, to be familiar with instruments and techniques useful in prospecting, and to acquire a knowledge of the economics of mining and marketing atomic source materials. Research geologists, mineralogists, and chemists will find a host of unsolved problems such as the basic mineralogy of uranium in phosphate rocks, the preference of hydrothermal uranium deposits for Pre-Cambrian shield areas, and the effect of secondary enrichment on deposits of radioactive minerals.

In describing the "carnotite deposits" of the Colorado Plateau, Richard P. Fischer noted that the commercial concentrations are related to a few stratigraphic zones along which they are widespread but spottily distributed. These irregularly tabular and lenticular deposits appear to occupy the thicker and coarser-grained parts of channel sandstones and were probably deposited by circulating ground water solutions after the enclosing sands had accumulated but before regional deformation. The USGS has been making detailed studies of the geological environment of these deposits.

Relaxing between atomic mineral sessions at the Annual Meeting are USGS members (L to R) V. E. McKelvey; R. P. Fischer; Lincoln R. Page.

In a paper on the characteristics of marine uranium-bearing rocks, V. E. McKelvey noted that significant but variable amounts of uranium are contained in phosphorites and in many dark-colored organic marine shales throughout the world. Rocks of this type apparently have been deposited in marine basins during periods of quiescence when accumulation of clastic material and precipitation of carbonate rocks was at a minimum. The method of fixation of uranium in the sediments has not yet been demonstrated, but several processes appear to be possible such as adsorption by clay or organic matter and isomorphous substitution for calcite in fluorapatite. Recognition of the fact that certain types of marine sedimentary rocks are more likely to contain significant amounts of uranium than others is of great importance to the prospector and exploratory geologist, for it permits him to concentrate his efforts in areas that contain the most promising rock types. Questions concerning genesis and grade of marine uraniferous deposits were raised by T. S. Lovering, Olaf P. Jenkins, Parker D. Trask, and Wilbur H. Grant.

Lincoln R. Page pointed out that uranium-bearing minerals are relatively common minor constituents of pegmatites but that only rarely are they of economic significance. None of the known domestic pegmatites can be mined for uranium alone, but it is

possible that uranium might be recovered as a by-product from some pegmatites that contain commercial quantities of feldspar, mica, or lithium minerals. Careful study of the internal structure of pegmatites has shown that the minor constituents are definitely related to specific and recognizable mineral zones. This predictable association greatly facilitates prospecting for and evaluation of the minor constituents of pegmatites.

W. F. James, Canadian mining geologist, pointed out that most of the radioactive mineral occurrences in Canada are in hydrothermal veins near the margins of the extensive Pre-Cambrian shield. He classified Canadian occurrences into six geologic groups and described the most important individual deposits.

Philip L. Merritt, assistant manager of raw materials operations of the Atomic Energy Commission, emphasized that high-grade pitchblende ores, such as those in the Erzegebirge region of Saxony and Bohemia, at Eldorado on Great Bear Lake in Canada, and in the Shinkolobwe deposit of Belgian Congo, are the most acceptable materials for atomic energy but that at some time in the future, low-grade ores will undoubtedly have an important role in atomic energy development. He also expressed the firm conviction that normal competitive operations of the mining industry will prove the most effective way in which to assure a constant, plentiful supply of uranium—the world's most strategic material.

Sixteen papers were presented at three sessions on mineral resources and ore finding. Stimulating philosophical papers by Samuel G. Lasky, D. F. Hewett, and James D. Forrester called attention, respectively, to the need for and suggested approach to a national mineral resources appraisal, to the opportunity and need for research in the field of economic geology, and to the desirability of adapting curricula in mining geology to the problems of mineral exploration. H. E. Hawkes, Jr., in reviewing the progress of research and of the practical application of geochemical methods to the search for ore, stressed the fact that the development of rapid and relatively accurate techniques for determining minute quantities of metallic elements in soils, waters, and plants has made it possible to increase greatly the collection of field data. The work to date in this relatively new field suggests that it may become a valuable tool in the search for certain types of metallic ore deposits.

Examination of many ore deposits ranging in age from Pre-Cambrian to Tertiary has suggested to Harrison A. Schmitt that certain types of ore deposits and certain mineral associations are characteristic of, and possibly restricted to, different periods of geologic time. As pointed out in discussion by A. E. J. Engel, this suggestion contrasts sharply with the defense of uniformatarianism recently presented by James Gilluly.

At Steamboat Springs in western Nevada, nature has provided an ideal laboratory for the study of epithermal and telethermal deposits, for these springs are currently depositing significant, albeit noncommercial quantities of mercury, antimony, gold, and other metals. The investigations of Donald E. White and George Thompson in this area are furnishing valuable data on the chemistry, temperature, activity, and deposits of these hot springs, and should lead to a more complete understanding of the processes responsible for hydrothermal ore deposits.

Mr. Engel's studies of 1200 epithermal and telethermal veins in the Ouachita mineral province of Arkansas have clearly demonstrated the relationship of these veins to structural features and have given valuable information on the composition, temperature, and direction of movement of the vein-forming solutions.

Much has been written concerning the alteration of host rocks adjacent to hydrothermal ore deposits. But, to my knowledge, Reno Sales and Charles Meyer are the first to present convincing field and laboratory evidence to support their conclusion that at Butte alteration of the granitic host rock and formation of the ore veins were accomplished during a single period or wave of mineralization. In a paper published last year, the writers described wall rock alteration at Butte. Now they convincingly demonstrate that rock alteration and vein growth result from an encroaching or migrating replacement front at whose distal extremities the granitic rocks are being slightly altered, while simultaneously, nearer the source of the solutions, a complex series of ore-mineral replacements is taking place. The result of this process is a zonal arrangement of sulphide minerals within the veins and a zonal arrangement of altered rocks enveloping the veins.

Bronson Stringham recognizes several stages of rock alteration prior to ore deposition at Bingham, Utah. Mr. Lovering inquired whether there is any evidence to suggest that solutions effecting alteration at one point might have been depositing ore at another. Professor Stringham interprets the fact that only quartz is associated with the ore minerals to indicate that ore deposition was probably later than rock alteration.

Close spatial and time relationship of lamprophyre dikes to certain types of ore deposits in British Columbia have been observed by H. C. Gunning and associates. More detailed studies of these relationships may give fundamental data on the time relationship of ore deposits and associated igneous rocks and possibly also on the nature of the ore-forming fluids. Mr. Schmitt, in discussing the paper, suggested that the relationships described might be expected according to the cupola theory of ore genesis.

Roger H. McConnel clearly presented a working hypothesis to explain the origin of observed structural features in the Coeur d'Alene district of northern Idaho and explained in some detail the relationship of known ore deposits to these structural features.

The geology of three metal mining districts in California was described by geologists of the USGS. In describing the geology of the Shasta County massive sulphide deposits, A. R. Kinkel and J. P. Albers stimulated discussion by B. S. Butler and George Seager on the origin of the controversial Balaklala rocks. The origin of these rocks has a direct bearing on the search for ore in this district and consequently should be established beyond question. Charles W. Merriam, in describing the geol-

ogy of Cerro Gordo mine area, pointed out the close relationship of ore to a 250-ft thick series of interbedded Devonian limestones and quartzites and the significance of the relationship in the search for ore. The geology of the contact-metamorphic tungsten deposits of the Bishop district was clearly presented by Paul C. Bateman.

In the field of mineral economics, R. F. Helmke described the noteworthy expansion of the western iron and steel industry during the past decade and J. J. Collins presented an interesting summary of Japan's copper industry in which he briefly described the economics of this industry along with a brief statement of geology, output, and reserves of the principal deposits.

Geophysicists Cover Broad Program

REPORTED BY SHERWIN F. KELLY

Two geophysics sessions held on Thursday at the Fairmont Hotel covered a geographical range from South Africa to the Arctic Circle, and in subject matter treated magnetometry, gravimetry, radioactivity, bacteriology, and biogeochemistry, as well as the economics of mining geophysics and geophysics education. The morning session, under the joint chairmanship of J. J. Jakosky and James B. Macelwane, started off with an account, presented by G. D. Garland, of gravity work on the East Sullivan sulphide deposit near Val d'Or, Que. Prior gravitational work had run into trouble because overburden effects masked those from the ore body. The authors divided the gravitational effects into first order anomalies due to deep crustal features, second order anomalies caused by belts of dense lavas in granitic rocks, and third order anomalies due to sulphide bodies. They found that for a massive body, such as the one being studied, the gravitational anomaly would disappear if the deposit lay at a depth of 500 ft. A paper by Charles R. Holmes, read by G. D. Garland, dealt with magnetic fields associated with igneous pipes in the Ozark region. The work was carried out in the southwest part of St. Genevieve County, Mo., where there are several igneous intrusions in the form of pipes and dikes. The magnetic indications obtained were checked and confirmed by gravitational work. The radioactivity observable at the Caribou mine in Colorado was described by G. C. Ridland He showed curves of relative radioactivity at various levels in the mine which developed the fact that the radioactive mineralization

The USGS new portable Geiger counter is tested by Elizabeth Ross, Virginia Smithson, and the Survey's F. W. Stead.

was strong at depth, but practically unnoticeable at the surface.

The trials and tribulations of airborne magnetometer work in the northern part of Sweden were graphically described by Hans Lundberg, with a number of interesting slides. He presented magnetic data obtained with his air-borne magnetometer over the strongly-magnetic iron deposits of northern Sweden. Turning from the Arctic Circle to South Africa, airborne magnetometer work on the latter continent was described in a paper by Oscar Weiss, presented by Father Macelwane. By means of a combination of gravity meter and air-borne magnetic work, valuable structural information was obtained on the relationship of the Witwatersrand sedimentary system to a partially concealed granitic plug. The effect on both sediments and igneous intrusive of an associated system of faults was also deduced from the combined results. The morning session was brought to a close by Mr. Jakosky, who gave a thoughtful evaluation of the relative roles played in mining exploration and oil exploration by geophysical techniques. He pointed out that the mining industry spends a far smaller percentage of its income on geophysics than does the oil industry, and it consequently reaps commensurately smaller benefits therefrom.

The afternoon session began with a description of Geiger counter work by Henry Paul. The effect of bacteria in promoting the plasticity of clay was then described by A. J. Frank. Clay strata under some building foundations in St. Louis had yielded to the point of causing cracks to appear in the building walls. Laboratory studies indicated that the bacteria could be killed or eliminated by d-c electric current. An ingenious scheme for a simple temperature compensation of the old-style magnetometer systems was described in a paper by Theodore Koulomzine, presented by Father Macelwane. The latter also discussed geophysical education in the United States and Canada, and revealed that there are 19 institutions in the United States and 7 in Canada which give instruction in mining geophysics. The activities of the geophysical section of the British Army during the war were given in the form of a letter from D. J. Simpson, presented by S. F. Kelly. This geophysical work greatly aided the campaign, particularly in Africa. by establishing water points ahead of the troops. Progress in the application of biogeochemical prospecting for tin, a program carried out in collaboration with Harry Warren, was reported by Mr. Kelly. The results obtained so far could not be called definitive, but are encouraging.

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Erle Daveler receives Certification of Honorary Membership from William Wrather at the Annual Banquet.

Biggest Technical Program Marks First Annual Meeting on Coast

REPORTED BY LEWIS A. PARSONS

Now that the 77th Annual Meeting of the AIME, and the first held in San Francisco, is over, there are few left who have not been convinced that a successful meeting can be held outside New York. This meeting is memorable not only because the technical program was the biggest in AIME history, but also because of the outstanding success of the many social events arranged to entertain visiting members and guests. Long-remembered by the 2000 in attendance will be the Annual Banquet, the All-Institute Luncheon, the St. Valentine's Day Dinner Dance, the Stag Smoker, the various Division lunches and dinners, and the well-attended program of the Woman's Auxiliary.

The ladies, perhaps, should be mentioned first, for without their charm and beauty none of the Institute events could have been as pleasant as they turned out to be. Under chairmanship of Mrs. H. Robinson Plate, the Woman's Auxiliary arranged a full program of its own. Attendance was extremely heavy, about 300, which was believed to be an all-time record for the Auxiliary.

The 1949 meeting reached its high point in the Annual Banquet which attracted 1065 members and their guests to the colorful Garden Court of San Francisco's historic Palace Hotel. It was there that the incoming and outgoing officers of AIME, together with the distinguished award winners, were honored by their fellow members. Before the Banquet began, there were two receptions for those who were later to be seated in places of honor on the dais. The warmth of heart and general conviviality brought much gaiety to the otherwise formal affair.

Robert Gordon Sproul, president of the University of California, gave an inspiring address stressing the great moral strength of the American way of life. Seating was arranged in tables of ten, each table graced by large sprays of western flowers. As a memento of the event, every lady present received a souvenir gold pan commemorating the California Gold Rush of 1849. Dancing began when the formal business of the evening was concluded, and many remained until two o'clock in the morning.

Attendance at 1949 Annual Meeting Compared to 1948

	1949 San Francisco	1948 New York
Men's registration.	1820	1804
Women's registration	338	226
Annual Banquet	1065	1125
Dinner-Smoker	462	845
All-Institute Luncheon	740	545
Informal Dance	575	522

The tremendous success of the entire social program was presaged on the first day of the meeting, when an overflow crowd gathered at the Fairmont Hotel to hear an address by Governor Earl Warren of California at the annual All-Institute Luncheon. Dr. Wrather introduced the guests at the speaker's table after which he presented William Wallace Mein, Jr., Chairman of the San Francisco Section and also of the Annual Meeting Committee, with a gold watch fob from the San Francisco Section in appreciation for his work in organizing the Annual Meeting. Next on the agenda was the announcement of winners of the Student Prize Paper Contest. W. E. Ellis, the only winner in attendance, received his award.

Governor Warren, in discussing the early history of California gold mining, said that the City of San Francisco was built by the gold miners and that in February of 1849 there were fewer women in San Francisco

Dancing after the formal banquet was fun and lasted until the wee small hours.

than presently attending the AIME meeting. To the amusement of everyone, he read an editorial from the *Engineering and Mining Journal*, commenting on a Regional Meeting held in San Francisco fifty years ago, which suggested that the pleasures of the meeting interfered with business and that these meetings might better be discontinued. The present-day AIME member seems to be able to take his technical sessions, hangovers notwithstanding.

That same evening, 575 enjoyed a St. Valentine's Day buffet dinner dance in the newly decorated Peacock Court at the Mark Hopkins Hotel. Music was by Ray Hackett's orchestra —a point of particular interest to mining men since Hackett got his start at one of the nation's well-known mining schools, the University of Nevada. The food, in the words of one happy delegate, was "beautiful to look at and wonderful to eat." California wines were placed on every table, and many Easterners became acquainted for the first time with the glorious bouquets developed by the vintners of the West. Excellent formal entertainment was provided in the main room during the course of the evening, but those in the back room, to whom this was not visible without leaving their tables, took things in their own hands. A group of well-known petroleum production men and their wives, arms entwined, stood around a table of long-haired beneficiation researchers and harmonized to the tune of "I Been Working on the Railroad."

Those who were lucky enough to attend are still talking about the Stag Smoker which was held in the San Francisco Commercial Club on the evening of Feb. 15. Professional entertainment was drawn from leading night clubs in the San Francisco area, but it took a pair of comparative amateurs to steal the show. The amateurs, Rip Borden and Phil Bradley, Jr., introduced a new scheme for national taxation which many delegates thought had excellent possibilities for development. So well received were their suggestions relative to Uncle Sam's excise taxes that they provided an encore in which the functions of the Institute's Board of Directors were explored.

On the same evening, the Petroleum Division held its Annual Dinner at the Fairmont Hotel. Reese Taylor, president of the Union Oil Co. of California, delivered an address entitled "The Greeks Had a Word for It." Petroleum Division Certificates of Service were presented to F. Julius Fohs and J. B. Umpleby. The Red Room, where the dinner was held, was filled to overflowing. Present, as indicated when called upon to take a bow, were many former chairmen of the Division and Institute officers, among the latter Directors Alford, Bowles, Millikan, Schumacher, and Suman. At the conclusion of the dinner Irwin W. Alcorn, Division Chairman, who presided, turned the gavel over to Lloyd E. Elkins, incoming Chairman for 1949.

In addition to the many Institute-sponsored affairs were numerous private cocktail parties. Notable among these was a function hosted by Dr. and Mrs. Frank Girard, Mr. and Mrs. Worthen Bradley, Mr. and Mrs. James Parks Bradley, and Mr. and Mrs. John D. Bradley, in the Girard home in Pacific Heights.

Section Delegates from forty Local Sections gathered on Monday for an all-day discussion of Institute affairs and the relation of the AIME to its members. The main problem discussed was the Institute deficit and the possibility of retiring it by raising dues. This situation was thoroughly aired during the entire morning meeting and during most of the afternoon. After due deliberation, the Section Delegates voted to recommend to the Board that, because of the serious financial plight of the Institute, appropriate steps should be taken to increase the annual dues of Members and Associate Members from $15 to $20, and of Junior Members from $10 to $12, effective for 1950 and for two years thereafter; further, that a referendum be taken in 1952 as to the dues for succeeding years in light of the financial position of the Institute at that time. It should be noted that "appropriate steps" will include a referendum of the members, as provided by the bylaws.

Among other important matters discussed was the proposal to hold fewer and longer Board meetings which would convene at various convenient points around the country. This would increase the importance of each meeting and increase Director attendance. Routine matters could be dealt with by the Executive and Finance Committees at monthly meetings, subject to approval later by the entire Board. The Delegates went on record in favor of this proposal.

Before adjournment the Delegates voted to express their appreciation to the San Francisco Section for their hospitality at this Annual Meeting and to thank Dr. Wrather for his outstanding service to the Institute as President in the difficult year just passed.

technical program

The technical program was bigger than ever before, being comprised of some 60 sessions covering all phases of the mineral industries. The unity and purpose of the Institute meetings were best expressed by the number of joint sessions between various Divisions. Outstanding examples of this joint interest were such sessions as the Minerals Beneficiation Division and the Iron and Steel Division on "Pyrolysis and Agglomeration"; and Extractive Metallurgy, Industrial Minerals, and Iron and Steel Divisions on "Titanium."

Educators convened on Sunday on the beautiful campus of the University of California in Berkeley for afternoon and evening sessions which were interrupted only by cocktails and a buffet supper. The other Divisions and Committees of the Institute began their technical programs on Monday, many lasting for the full four days. The Society of Economic Geologists met jointly on Tuesday and Wednesday with the Institute's Mining Geology Committee. As usual, Division and Committee luncheons served the joint purpose of satisfying the inner man and conducting the annual business meeting of the group. The luxurious dining rooms of the Fairmont, Mark Hopkins, Clift, and Bellevue Hotels provided attractive settings for these affairs. Numerous motion pictures, mostly through the courtesy of the Bureau of Mines, added interest to the technical sessions.

Affairs of the Metals Branch of the AIME were conspicuous in the program. There were 28 sessions, including technical papers, luncheons, and lectures. The number of papers was over 65 and usually the formal papers were followed by lively discussions. Nor were those who discussed papers shy in taking exception to theories presented.

One of the main events was the Institute of Metals Division lecture by Egon Orowan, Cavendish Laboratory, Cambridge, England, on "Structure of the Cold-worked Metal." Equally well-received was the Howe Memorial Lecture on "What Is Metallurgy?" by John Chipman, head, department of metallurgy, Massachusetts Institute of Technology. In place of the usual Institute of Metals Division dinner and the Iron and Steel Division luncheon, a successful Metals Branch luncheon attended by an even 100 inaugurated the formation of the Metals Branch.

The technical program of the Petroleum Division began on Monday afternoon with a review of foreign and domestic production. On Tuesday morning there were three papers on economics subjects and the Wednesday morning and afternoon sessions were devoted to petroleum technology. Mr. Elkins presided at the open session of the Executive Committee for 1949 on Thursday morning.

Detailed reports of the various Division and Committee technical sessions appear in Section 1 of the appropriate Branch journals.

An airplane trip over San Francisco was conducted on Wednesday and Thursday through the courtesy of Pan American Airways. V. L. Vanderhoof, of Stanford University, accompanied the trips and pointed out sights of cultural and industrial importance in addition to giving an interesting commentary on them.

Olaf P. Jenkins took about 23 in a Greyhound bus on a field trip to see the sights and geology around the Bay area. The day was bright and sunny and so everyone was in good spirits as the trip started across the Bay Bridge and toured the Berkeley Hills returning to Richmond on the ferry. An excellent luncheon was enjoyed at the Hamilton House in Fairfax. The party continued to Olema on the San Andreas fault and finally returned to San Francisco across the Golden Gate Bridge. Another trip was led by Edgar Bailey to study the geology of the New Almaden quicksilver area. Both of these trips were enjoyed by all who participated. About a dozen people signed up for the post-meeting trip to Hawaii which was a 6 to 10 day tour of the interesting points of the Islands. It will be a long time, if ever, before the many enjoyable experiences of the 1949 meeting in San Francisco are forgotten.

The general committee, headed by William Wallace Mein, Jr., the finance and banquet committees headed by Walter L. Penick, the entertainment and hospitality committee headed by Worthen Bradley, the reception committee headed by Richard D. Moody, the dinner-dance committee headed by P. R. Bradley, Jr., the stag smoker committee headed by Herbert A. Sawin, and the All-Institute luncheon committee headed by George H. Playter worked hard to make every event a success.

The San Francisco Section and the Institute as a whole acknowledge gratefully the contributions which so greatly helped in making this meeting possible. Among the contributors were:

Allis-Chalmers Manufacturing Co., American Brake Shoe Co., American Cyanamid Co., American Forge Co., American Rubber Manufacturing Co., American Smelting and Refining Co., Apache Powder Co.

Baroid Sales Division, National Lead Co., Bishop Oil Co., Bradley Mining Co., Braun-Knecht-Heimann Co., E. D. Bullard Co., Bunker Hill & Sullivan Mining and Concentrating Co.

Calaveras Cement Co., California Wire Cloth Corporation, Capital Co., Chicago Pneumatic Tool Co., Coast Manufacturing and Supply Co., Crucible Steel Co. of America.

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Thomas A. Edison, Inc., Electric Steel Foundry Co., Electric Storage Battery Co., Empire-Star Mines Co.

Gardner-Denver Co., General Electric Co., Gold Hill Dredging Co., Goldfield Consolidated Mines Co., H. W. Gould & Co., Great Western Division, Dow Chemical Co.

Abbot A. Hanks, Inc., Hanna Coal and Ore Corp., Homestake Mining Co., Honolulu Oil Corp., Humphreys Investment Co., Hardinge Co.

Ingersoll-Rand Co.

Joy Manufacturing Co.

Kaiser Iron and Steel Co., Kennecott Copper Corp., Knob Hill Mines, Inc., Kennametal, Inc.

Link-Belt Co., Le Roi Co., Cleveland Division.

Marsman & Co., B. F. McDonald Co., McGraw-Hill Publishing Co., Merrill Co., Metal and Thermit Corp., Mine Safety Appliances Co.

Nevada-Massachusetts Co., Nordberg Manufacturing Co.

Oliver United Filters, Inc.

Pacific Coast Aggregates, Inc., Permanente Cement Co.

Quaker Pacific Rubber Co.

Shell Oil Co., Sonoma Quicksilver Mines, Inc., Sperry-Sun Well Surveying Co., Standard Oil Co. of California, Stephens-Adamson Mfg. Co.

Taylor-Wharton Iron and Steel Co., Tide Water Associated Oil Co., Timken Roller Bearing Co., Thurman Gold Dredging Co., Traylor Engineering and Manufacturing Co., Tyler Co., W. S.

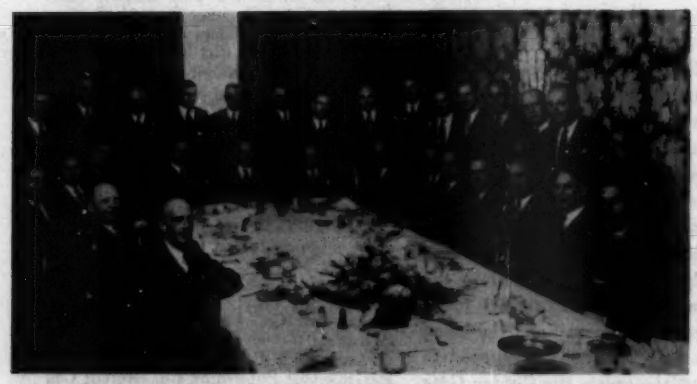
Union Pacific Coal Co., Utah Construction Co.

Western Precipitation Corp., Western Machinery Co., Westinghouse Electric Corp., Wildberg Bros. Smelting and Refining Co.

Yuba Manufacturing Co.

San Francisco drew a crowd for the Annual Meeting; here members register, meet old friends, and make new ones.

Seen at the Annual Meeting



But on Friday, before the clans gathered, some of the men responsible for the meeting's success attended a kick off luncheon.

With the meeting in full swing, Alice Fischer, only feminine metallurgist registered, meets President Young.

All-Institute luncheon fare was excellent (left) with Governor Warren (above) as pièce de résistance. L. E. Young and William Wrather are seated on either side.

Omaha Public Library
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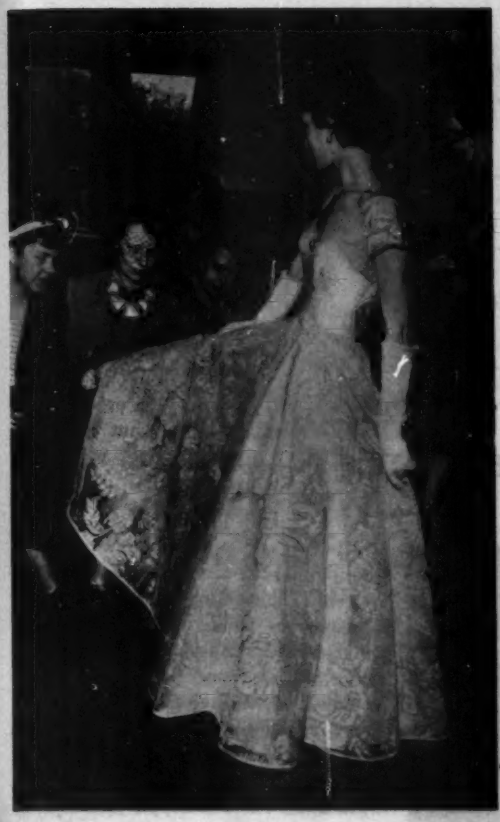


A Don Loper original of imported lace embroidered in an overall fern pattern with silver threads modeled during the Woman's Auxiliary fashion show; lovely, isn't it.

Bain, McLaughlin, Fischer, and Page discuss atomic mineral deposits; (below) R. F. Davis speaks on petroleum refining at an MIED session, flanked by G. C. Gester and E. DeGolyer, moderator.

Dancing brings the Banquet to a pleasant close. It also marked the end of the formal social functions, but not the end of gatherings of friends in lobbies and corridors, and sightseeing in San Francisco. Thanks are certainly due to every one concerned with making the meeting a success.

Robert L. Hoss receives the Alfred Noble prize from President Wrather. (Below) James Boyd, E. H. Robie, and Earl Warren chat at the All-Institute luncheon.

Controversy on Mineral Supplies Marks Mineral Economics Session

O. P. Jenkins, W. T. Hannum, and Governor Warren talk over mineral supplies as W. E. Wrather smiles on the gathering.

REPORTED BY JOSEPH T. SINGEWALD, JR.

A national mineral policy symposium comprised four papers covering a survey of domestic deficiencies and potential foreign sources by Alan M. Bateman, a consideration of critical factors affecting the domestic mining industry by Otto Herres, Jr., a review of progress in stock piling by Richard J. Lund, and discussion of the role of government in a national mineral policy by Donald H. McLaughlin. Elmer W. Pehrson and Charles H. Behre, Jr., served as chairman. Though replete with fruitful thought, the symposium resulted in no definitive solution of the complex problems of to what degree and how and when our domestic resources should be drawn upon and to what degree our domestic resources should be conserved by drawing on foreign supplies. The incompatibility of maintaining a strong domestic mining industry and not depleting our reserves presented a baffling problem.

Bateman's paper was presented by Mr. Pehrson. The war demands increased the former dozen strategic minerals to five dozen, of which 27 came only from foreign countries. Our own demand for many of them exceeded the existing world supply. The postwar demand has remained at the wartime level. The author is more optimistic over our mineral resources than the estimates in "The Mineral Resources of the United States," but emphasized the urgent need for the United States to become more internationally minded in providing the mineral needs of the future. Realignment of the sources from which we can supply our deficiencies due to developments in the international situation were described, including the dropping of the "iron curtain," which has either shut off or made precarious some of our most important sources of the past. Thus private industry alone can no longer be relied upon to assure the United States adequate mineral supplies from abroad, but must be supported through diplomatic channels. H. DeWitt Smith cited wasted war effort to supply our needs of such metals as manganese from domestic sources to the neglect of adequate foreign sources.

Mr. Herres pointed out that our domestic mining industry is not as strong as the record 1948 dollar volume might suggest, because we are operating under both a peacetime and a wartime economy determined by political interests that are diluting our dollars. Weakening factors are: higher wages not compensated for by added production, high taxes that destroy venture capital, removal of tariff protection, and neglect of the mining industry by the planners who are determined to support many other things by government subsidy programs. He warned that we should heed the lesson of Europe, which amassed great wealth by selling goods to all the world only to waste its riches and resources in the devastation of war, by preserving our economic strength. Arthur Notman advocated conserving our limited resources and meeting current needs from the resources of our potential enemies, and Olaf Jenkins stressed the need to preserve stock piles for national defense instead of redistributing them as the threat of war decreases.

Richard Lund and Otto Herres at the symposium on national mineral policies.

Morris Muskat brings home a point at a MIED session. Also at the speaker's table are R. F. Davis, E. DeGolyer, A. C. Rubel, and C. A. Heiland.

Mr. Lund outlined the history of stock piling, the need for which was recognized during World War I and, although urged by the experts, was neglected during the 20's and 30's. Substantial progress was again made during World War II, but the lessons of that war were again forgotten, and sizable stocks of strategic materials were quickly legislated into peacetime consumption. The Berlin crisis forced a belated recognition that the stock pile is a high priority claimant. Stock piling was started over again so that by the end of 1948 all available funds had been spent or committed. Stock piling should not be restricted to foreign sources, but should include utilizing most economically low-grade domestic deposits. It was pointed out that in a future emergency, power will be a severe bottleneck, and it should be stored by stock piling metals rather than ores. Philip R. Bradley, Jr., advocated the development of self-sufficiency through the encouragement of a wide search for mineral deposits under favorable government policy ratner than through the short-sighted policy of government subsidies. W. D. Johnston, Jr., cited the newly established Brazil-United States Technical Commission which is planning the development of vast iron and manganese resources in Brazil by private capital.

Dr. McLaughlin advocated a national mineral policy of free enterprise under reasonable control. He regarded subsidies as undesirable, but needed if profits are sucked by taxes to be redistributed according to bureaucratic social control. A guaranteed price would stimulate private enterprise at home, and government support is needed to increase foreign supplies. Both tax relief and financial aid cannot be had at the same time. He hoped that money and man power will not be wasted again, however, in searches for materials which we don't have. Though pleading for economy in government expenditures, he recognized the value of research and regional survey by the U. S. Geological Survey and the Bureau of Mines. Cooperation of government and industry in discovery during the war was approved, but the final steps of development should be left to industry. Ira Joralemon and Arthur Notman both endorsed his views. Though competitive free enterprise was accepted as the soundest national mineral policy a heavily-taxed mining industry was bound to lean to some extent on government aid.

Educators Discuss Effects of Research on Education Trends

REPORTED BY J. D. FORRESTER

Under the general leadership of its Chairman, Curtis L. Wilson, the Mineral Industry Education Division held three sessions in San Francisco and Berkeley during the 1949 Annual Meeting. Following the usual custom of meetings which are held by the Division, the first session began at 2:30 Sunday afternoon, Feb. 13, in the Hearst Mining Building of the University of California, Berkeley, and continued into Sunday evening, after cocktails at the Claremont Hotel and an excellent buffet supper at the Men's Faculty Club. The second and third sessions were comprised, respectively, of a technical program on Monday morning and a business meeting luncheon on Tuesday. Attendance at the different meetings was good and the interest maintained throughout the sessions was extraordinary. Eighty-five were present at the Sunday meeting, 40 members attended the Monday technical session, and 18 were present at the luncheon.

The general theme adopted for the Sunday sessions, which served as a guide for the formal speeches, was "Mineral Engineering Education of the Future in the Light of Present Day Research Problems." Several outstandingly informative talks were of-

fered on various aspects of the subject. David R. Mitchell read Dr. Lawall's paper, Fred C. Bond offered an analysis of F. T. Agthe's manuscript, and R. F. Davis read Dr. Egloff's paper. All other papers scheduled for the Sunday program were presented by their respective authors. As evidence of the capacity of the speakers and of the timeliness of the general topic, each of the contributions led to extensive discussion by the assembled members.

J. R. Van Pelt and Everette DeGolyer served, respectively, as moderators of the Sunday afternoon and evening sessions. They stressed the advancement made by industry through academic and industrial research and cited the importance of fundamental experimentation as demonstrated by the tone and caliber of the talks offered by the speakers of the forum.

The Monday morning program was held in the Mark Hopkins Hotel in San Francisco. Analyses were offered of curricula in various phases of mining and metallurgy, and statistical data of graduate and undergraduate enrollments in schools of the mineral industry were presented. Harry E. Nold's paper on registration of engineers was given by Dean Wilson and William B. Plank's and Edward Martinez's contribution was read by Robert T. Gallagher. All other papers were delivered by the respective authors.

At the luncheon-business meeting of the Division held in the Clift Hotel, it was announced, by Dean Wilson, that Messrs. Gallagher, Thomas L. Joseph, and Ben H. Parker had been elected to the Executive Committee of the Division. They will serve until February 1952. Other officers of the Mineral Industry Education Division will serve during 1948-49. In closing the business meeting Dean Wilson expressed his appreciation to all participants in the programs of the Division. He gave special thanks to Dr. Gallagher for his splendid service as Program Chairman and to Lester C. Uren and Carlton D. Hulin for their joint efforts as hosts of the Sunday meetings held on the University of California campus.

Students Question Industry on Prospects

REPORTED BY JOHN V. BEALL

Mineral industry students gathered, about seventy strong, from four different colleges at the annual meeting in San Francisco for the second in what is hoped will be a series of student forums at AIME meetings. The series started auspiciously at the El Paso Regional Meeting and continued in San Francisco in what would have been a rapid fire question and answer session if the answers were as easy to give as the questions were to ask. Schools represented were the University of California, Stanford, and the Universities of Nevada and Arizona. Jay Carpenter, of the University of Nevada, was moderator and was supported by "elders" (we don't know who thought up this term but everybody got a kick out of it) L. E. Young, representing coal; James A. Barr, Sr., industrial minerals; James A. Barr, Jr., research; Barney Haffner, metal mining; Richard Moody, manufacturing; Harold J. Clark, petroleum; and Ira Joralemon, mining geology.

supply jobs open

Professor Carpenter was introduced by Lawrence Wright, who, incidentally, can moderate for us anytime. Jay quickly found out who his audience was by a fast poll which elicited the following facts: most of the students were from the University of California; roughly 25 were miners, 25 petroleum engineers, the rest being split between geology and metallurgy; 50 per cent married; 70 per cent veterans; and lo! one lovely lady miner. Without further ado, Mr. Moody was given the floor to describe the training program of Allis-Chalmers which he said was not unlike those of Ingersoll Rand, General Electric, and Westinghouse. In brief, the course is 18 months long, with the applicant going to Milwaukee where he is processed through the shop, design, research, and sales departments during that period. An aptitude test is given to help him decide which of the fields he would like to follow; design, research, or sales. Starting pay is around $250 and is raised to $270 by the end of the course. While in training, a man can go on and take a master's degree. Mr. Moody pointed out that sales work was engineering because equipment is sold on its engineering merits, its ability to do a particular job; and therefore salesmen must be able to help customers with their engineering problems. These companies hire all types of engineers. Our lady miner, Mrs. L. R. Miller, asked if the course was open to women. Mr. Moody said that they had never had a woman take the course but he didn't see why one couldn't. Mr. Barr, Sr., volunteered that he had a woman chief of party and a chemist, both of whom had gotten along fine.

opportunities in large vs. small companies

The question was raised from the floor as to whether it was better for a graduate beginner to work for a big company or a small one. Barr, Sr., commented on his experience in starting with a small company, but moving shortly afterward to International Minerals and Chemical with which organization he has been ever since. His feeling was that a young man got more experience with a large company. On the other hand Mr. Barr, Jr., had moved 25 times in his early days with the idea of seeing as much as he possibly could. He thought this was a good procedure if you had a wife who could take this kind of treatment. He is now a research man

for Armour. Mr. Haffner, who is general manager for Bunker Hill & Sullivan, thought that a man should go with a large company where he can learn something and then size up the situation as opportunities for transfer occur. Mr. Haffner is an exponent of the young mining engineer starting in production. Mr. Joralemon was of the opposite inclination. In a small company you learn more as you have to do a little bit of everything.

Dr. Young, who is a coal mining consultant as well as President of the AIME, outlined the procedure followed by a progressive coal company with a recent graduate. The young man is put into production work, either being shifted through various production jobs, or put on time study, or safety. At the end of three years he should apply for a qualifying certificate from the state in which he is employed. Starting salaries are set equal to the rate paid by any other industry in the area. Dr. Young followed a policy, when he was managing, of raising the man $25 every six months if he was worth it or firing him if he couldn't make the grade. He was of the opinion that large companies had a better organized training program than small companies. Putting a man in the surveying department of a coal company was a mistake in Dr. Young's opinion as the work of that department has to do chiefly with reserves and property lines and requires an intimate knowledge of the company's holdings. Also there would not be an opportunity to learn production work in this department. Dr. Young explained that a young man must broaden his knowledge after graduation on his own initiative. He should study economics, labor relations, and government in order to build a background suitable for promotion to the higher echelons of company organization.

foreign work discussed

On the request of the students, the question of the advantages or disadvantages of foreign work were discussed by the "elders." Mr. Barr, Sr., said that it was a question of whether you wanted to stay abroad or not, as the opportunities for advancement were good if you remained abroad but on the other hand it was hard to get a comparable job in the States after you had been foreign for a while. Professor Carpenter opined that to get into pioneering you had to go abroad. The biggest problem in this sort of work, he maintained, was the frequently adverse living conditions. However, in his opinion, one did not lose contact with people at home. In a reminiscent frame of mind, Jay went on to say that students didn't go leasing these days as they did in the old days. Until you had gone bust on a lease you hadn't cut your teeth in the mining profession. This brought a chuckle from the "elders." There was a decided note of nostalgia for the romance of mining in the old days in this soliloquy. Jim Head, a Chile Exploration man, was asked for his opinion on foreign work. Jim said that he wouldn't take anything in exchange for his years abroad and the contacts he made were the pleasantest of his life. In explanation to the students of the difficulties in taking one's wife abroad which is prevalent with many companies, he stated that housing was short and the mining companies were working to remedy this situation. As a word of caution, Mr. Head said that there was no quick road to the top in the mining industry.

advanced degrees depend on individual

The question of whether a man should work for an advanced degree or not was raised and Dr. Young replied that if the man was going into production work, he should get some experience first. Joseph T. Singewald, Jr., professor of economic geology at Johns Hopkins, suggested that field work was essential for a student who wished to take an advanced degree in geology. However, this work could be done during the summer with the USGS or with operating companies while the man was completing his course.

Opportunities for geologists in exploration were outlined in response to questions raised by the students. Mr. Joralemon said that they were excellent, particularly in foreign exploration, as so few men are willing to go. He pointed out that a good man can make just as big a name for himself abroad as by working at home. Mr. Haffner said that they used geologists at Bunker Hill and that the attitude of operators toward geologists has changed in recent years. Formerly the operator thought the geologist was only good for telling how the ore got there after the operator mined it. Mr. Haffner went on to say that most mines now used geologists to aid in development and that at his mine $300 was the starting salary.

older students not at disadvantage

Since most of the students were veterans of World War II, their average age was higher than in normal years. Hence the question was raised as to whether these older men were at a disadvantage after graduation. Professor Carpenter answered this pertinent question by assuring them that their wartime experience in human relations and handling men more than made up for their late start in industry.

S. S. Arentz, general superintendent at Pioche for the Combined Metals Reduction Co., wound up the meeting with a few amusing anecdotes from his experience as a mine operator which pointed up the fact that understanding the miners was the operator's most important job and the best way to learn to do this was to work as a miner.

Scholarships from Coal Industry

Scholarship awarding has been added to the ever-growing activities of the bituminous coal industry. Various coal companies and associations who want to improve mining community life and create a pool of available engineering personnel for the bituminous coal industry are currently providing 94 college scholarships. Among the seventeen organizations offering the scholarships are the Central Appalachian Section of AIME, with three, and the Coal Division of AIME, with two.

Jane Rees models an embroidered lace evening dress at the fashion show sponsored by the Woman's Auxiliary.

Woman's Auxiliary Enjoys San Francisco's Hospitality and Social Events

REPORTED BY MRS. E. H. ROBIE

Setting a standard of hospitality that will be difficult to equal, the committees of the Woman's Auxiliary under the efficient direction of Mrs. H. Robinson Plate, with the generous financial and personal support of the San Francisco Section, planned and carried out a successful program of entertainment for the ladies at the Annual Meeting of the AIME.

On Sunday evening, Feb. 13, the first social gathering, a cocktail party in the spacious home of Dr. and Mrs. Frank Girard, gave over 400 members a pleasant opportunity to meet old friends.

Monday morning 288 women registered in the lobby of the Fairmont Hotel. Most of the ladies decided not to miss any of the interesting affairs scheduled for their entertainment.

Governor Warren of California held the attention of those who attended the All-Institute Luncheon on Monday. It is easy to understand why he is the choice of both Democrats and Republicans in his home state.

Monday evening the Informal Dinner Dance in the artistic Peacock Court of the Mark Hopkins Hotel was a great success. Guests were seated at small tables lighted by hurricane lamps and served themselves at the buffet supper placed at one side of the room. The food was so artistically prepared and arranged that it was an added decorative feature. Amusing entertainers appeared during the evening and a fine orchestra made dancing a pleasure.

The Annual Meeting of the Auxiliary on Tuesday morning at the Mark Hopkins Hotel, presided over by the president, Mrs. Thorne E. Lloyd, was notable for its brief informative section reports under the direction of Mrs. H. A. Prosser. Lewis E. Young, President of AIME for 1949, addressed the meeting briefly, emphasizing the value of the work of the Auxiliary especially in the field of educational scholarships. A number of young, brilliant men whom he has known have been able, through these scholarships, to prepare for engineering careers.

Mrs. H. W. Hardinge, Chairman of the Chest Committee, reported briefly on the National project, the rehabilitation work under Howard Rusk at the New York Hospital.

Luncheon at the Top of the Mark followed. From the glass enclosed observation tower, the harbor, the Oakland and Golden Gate Bridges, and much of San Francisco can be viewed. It is a favorite spot at the cocktail hour when the colors of the setting sun fade and in the twilight that follows the twinkling lights of the city give a jeweled outline to bridges, buildings, and landscape below.

After luncheon we were driven by bus and private cars to tea at the home of Mr. and Mrs. W. W. Mein. This beautiful residence, set in the hills on the peninsula beyond San Mateo, was designed by Sir Herbert Baker the architect who planned the home of Cecil Rhodes in South Africa.

On Wednesday Mrs. Newell Alford conducted an interesting round table discussion in the Bonanza Room at the Mark Hopkins Hotel. A number of helpful ideas were brought out. Emphasis on the personal approach in Auxiliary affairs was stressed. Some membership chairmen telephone prospective members and many write personal letters. It was suggested that new members be appointed to working committees, also that older members make a special effort to talk to new members at meetings and so make them feel like part of the group. The round table was followed by a luncheon fashion show at the St. Francis Yacht Club where attractive mod-

els displayed the smart clothes so well that many guests hurried to The White House to get first choice of the well designed costumes. Buses and cars carried the guests back to San Francisco past the Yacht Basin to the Fairmont Hotel, a distance of five miles.

The Palace Hotel was the setting for the Annual Banquet Wednesday evening where a delicious dinner was served. President Wrather presented the special awards and medals and greeted Dr. Young as President of AIME for 1949. The ladies were presented with attractive silver pins in the shape of a miniature California gold pan, the gift of the contributors to the Annual Meeting entertainment fund. This favor appropriately marked the centennial celebration of the discovery of gold in California. Robert G. Sproul, president of the University of California, made the address of the evening. Dancing followed the formal ceremonies and many stayed until one a.m. to enjoy the last strains of the orchestra.

Although the banquet marked the end of formal social functions the corridors and lobbies of the hotels were filled with friends on Thursday and Friday. These last two days afforded time for trips to the attractive shops, to Chinatown, Fisherman's Wharf, and to the homes of friends. A number of fortunate women accompanied their husbands by plane to Honolulu.

Those who traveled by train through the snow blocked area of the middle west will recall the difficulties in reaching the Golden State of California in 1949. Many will remember the superb views of San Francisco, the cable cars, the cosmopolitan atmosphere of gayety, Chinatown, the fog that often blanketed the streets and muted the sounds of whistles from the harbor, all of which made their unique contribution to the setting for this successful Annual Meeting.

Woman's Auxiliary Girls Loan Fund Successful

A total of twelve girls have been put through school in the past eighteen years by the Girls Activities Loan Fund of the Women's Auxiliary, New York Section, AIME, and yet the original gift of $5000 remains untouched. The fund has $250 a year on hand to enable daughters of anyone, living or dead, associated with mining or metallurgy, to obtain a practical education which will prepare them to earn a livelihood. Recipients agree to repay one-half of the loan, and thus far eight of the twelve girls have done so. Expert management has enabled the ladies to pay out nearly $5000, and yet keep the original gift in the bank, in the form of stock. The New York Section's Women's Auxiliary will be glad to answer queries, and receive suggestions as to possible recipients.

Calendar of Coming Meetings

APRIL

1 Columbia Section, AIME.
4 Boston Section, AIME.
5-6 Metal Powder Assn., 5th annual meeting and exhibit, Drake Hotel, Chicago.
6 Chicago Section, AIME. Continuous casting at B&W Tube Co.
6-10 AIChE, regional meeting, Los Angeles.
7 Reno Branch, Nevada Section, AIME.
11 Mid-Continent Section, AIME.
11-14 National Assn. of Corrosion Engineers, 5th Annual Conference and Exhibition, Netherland-Plaza, Cincinnati.
11-15 Western Metal Congress & Exposition, Los Angeles, Calif., AIME and ASM, etc.
11-12 American Zinc Institute, annual meeting, Hotel Statler, St. Louis.
12 East Texas Section, AIME.
13 El Paso Metals Section, AIME.
13 San Francisco Section, AIME.
13 Southwestern New Mexico Section, AIME.
15 Oregon Section, AIME.
18 Detroit Section, AIME. W. L. Grube on the electron microscope.
18-20 Midwest Power Conference, Sherman Hotel, Chicago.
18-20 Open Hearth Conference, and Blast Furnace, Coke Oven and Raw Materials Conference, Palmer House, Chicago.
19 Gulf Coast Section, AIME.
19 Washington, D. C., Section, AIME.
19-21 AIEE, Southwest district meeting, Baker Hotel, Dallas.
20 Southwest Texas Section, AIME.
20-23 ASCE, spring meeting, Oklahoma City.
21 Carlsbad Potash Section, AIME.
21 North Pacific Section, AIME.
21 Utah Section, AIME.
22-23 New England Institute of Metals Division Regional Meeting, Hotel Sheraton, Springfield, Mass.
22-23 Engineers' Day, Colorado School of Mines, Golden.
24-28 American Ceramic Society, national meeting, Netherland-Plaza, Cincinnati, Ohio.
25-27 Canadian Institute of Mining and Metallurgy, annual meeting, Windsor Hotel, Montreal.
25 Alaska Section, AIME.
26 Montana Section, AIME.

MAY

2-4 ASME spring meeting, New London, Conn.
2-5 American Foundrymen's Society, 53rd annual meeting, St. Louis.
6-7 American Institute of Chemists, annual meeting, Chicago.
8-12 AICE, Tulsa, Oklahoma.
9-12 American Mining Congress, coal convention and exposition, Public Auditorium, Cleveland.
11-13 Engineering Institute of Canada annual meeting with International Management Congress hemisphere meeting, Chateau Frontenac, Quebec.
14 Northwest Industrial Minerals Conference under auspices of Columbia Section, AIME, Spokane.
May 16-June 3 U.N. Scientific Conference on Conservation and Utilization of Resources, New York.
23 Iron and Steel Division, AIME, annual May dinner, Engineers Club, New York City.
25-26 American Iron and Steel Institute, general meeting, New York City.

JUNE

16 Engineering Foundation, 29 W. 39 St., New York City.
June 27-July 1 ASTM, 52nd annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.
20-22 American Society of Heating and Ventilating Engineers, semi-annual meeting, Minneapolis, Minn.
20-24 AIEE, summer general meeting, New Ocean House, Swampscott, Mass.

JULY

9-23 Fourth Empire Mining and Metallurgical Congress, Great Britain.
13-15 American Society of Civil Engineers, summer convention, Mexico City.
15-24 Pan-American Engineering Congress, Rio de Janeiro.

AUGUST

23-26 AIEE Pacific general meeting, Fairmont Hotel, San Francisco.

SEPTEMBER

25-28 Regional Meeting, AIME, Nell House, Columbus, Ohio.
25-28 American Mining Congress, Western fall meeting, Spokane.
29-Oct. 1 Colorado School of Mines, 75th anniversary celebration.
Sept. 30-Oct. 1 Southern Ohio Section of Open Hearth Committee, AIME, fall meeting, Deshler-Wallick Hotel, Columbus.

OCTOBER

5-7 Petroleum Branch, AIME, fall meeting, Plaza Hotel, San Antonio, Texas.
17-19 Institute of Metals Division, AIME, fall meeting, Allerton Hotel, Cleveland.
17-23 AIEE, 1949 Mid-West meeting, Netherlands-Plaza, Cincinnati.
28 Pittsburgh Section of Open Hearth Committee and Pittsburgh Section, AIME, annual fall meeting, William Penn Hotel, Pittsburgh.

NOVEMBER

1-5 Pacific Chemical Exposition, California Section, American Chemical Society, San Francisco Civic Auditorium.
2-4 American Society of Civil Engineers, fall meeting, Washington, D. C.
7-10 AIChE, annual meeting, Pittsburgh, Pa.
12-14 Geological Society of America, annual meeting, Hotel Cortez, El Paso.

DECEMBER

8-10 Seventh Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.

FEBRUARY 1950

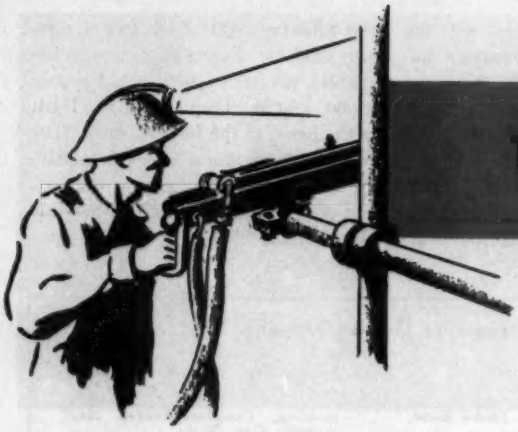
13-16 Annual Meeting, AIME, Statler (Pennsylvania) Hotel, New York City.

APRIL 1950

10-12 Open Hearth Conference, and Blast Furnace, Coke Oven and Raw Materials Conference, Netherland-Plaza Hotel, Cincinnati.

DECEMBER 1950

7-9 Eighth Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.



THE DRIFT OF THINGS

. . . as followed by EDWARD H. ROBIE

A "Have-Not" Nation

Palestine, and the new state of Israel, have been much in the news in the last year or two, but little has been said about its natural resources. We were therefore interested in a lecture given by S. H. Shaw not long ago before the Imperial Institute on the geology and mineral resources of the country. Briefly, we gather that whatever they have been fighting about in that part of the world, mineral wealth is not a consideration, as it is in so much of the world's strife.

The area of Palestine is only 10,400 sq mi—about that of Maryland or New Hampshire, and one tenth the size of Arizona, for instance—and of that a third is the southern desert or wilderness zone, roughly in Negeb and the part of the country to the south of it. Palestine is long and narrow—260 miles long, and the maximum width, between the Mediterranean and the Dead Sea, is 70 mi. It has three distinct topographical zones or strips running north and south — the coastal plain, the hill country, and the Dead Sea rift valley. It is practically all sedimentary country, not older than Cretaceous, with the hill country made up of hard and well-bedded Cretaceous and Eocene limestones, chalks, and dolomites. Pre-Cambrian country is limited to a few square miles at the southern tip, where micaceous schists and granite occur.

The most important mineral to the economy of the country is water, but there is not much of it over most of the area. Surface supplies are scanty almost everywhere, and in the arid parts of the country to the south water is practically unobtainable. Supplies are extremely scant in the hill country as well.

But the greatest mineral resource of Palestine lies in the water of the Dead Sea, which contains about 27 per cent of mineral matter, chiefly the chlorides of magnesium, sodium, calcium, and potassium, in that order, and magnesium bromide. Palestine Potash Ltd. has extensive treatment plants and produces potash, bromine, and salt, with plenty of magnesium chloride also available if anybody wants it.

The dolomitic limestones are extensively quarried for building stone, lime-burning, road stone, brick, and cement making, and use as a soil conditioner. Rock salt is obtained from solar evaporation of sea water as well as from treating the Dead Sea brine, and immense deposits can be mined if needed.

That about sums up the mineral resources. A little feldspar and barytes have been found, and unpromising deposits of sulphur, phosphate, manganese, and even copper are known. Three areas have possibilities of oil—the coastal plain, the Negeb, and the southern end of the Dead Sea, the last-named perhaps being the most promising, for bituminous limestones are present, which characterize so many of the oil fields of the Near East. A salt mountain exists here but it is perhaps not what oil men think of as a salt dome, for bedding exists in the salt, conforming with that of the sediments. But its presence does indicate the possibility of suitable structural traps for the accumulation of oil, although the faulted nature of the area may indicate that any oil has been dissipated rather than conserved. Exploration is going on.

Lack of mineral resources is always a handicap to a nation, though not a critical one, as many small nations have proved. The Jews are sufficiently resourceful and talented to find ways to make a living other than by the exploitation of mineral resources.

What Are Profits?

Proponents of wage increases for union labor, confronted with the argument that such wage increases will immediately be offset by higher prices, thus continuing the inflation spiral, reply that higher wages can easily be paid out of swollen profits and if capital would only be satisfied with a normal profit, no increase in prices would be necessary. It is true that profits of many if not most companies have been considerably greater than what might be considered normal, and that dividends have been consequently higher, but it is often forgotten that these profits and dividends are expressed in dollars and the dollar is now worth only sixty cents, or thereabouts. By the same argument, wages should revert back to the prewar scale.

We had in mind continuing on this subject for a paragraph or two or three when we ran upon a statement made by our own Joseph E. Pogue before a Congressional subcommittee on business profits, entitled "The Function of Profits in the Petroleum Industry." He states the matter much better than we could, and furthermore this is Washington's Birthday and we shouldn't have to work.

"The term profits," says Dr. Pogue,

"is a popular expression, the technical counterpart of which is 'net income.' Net income, or profit, however, at best is an accounting interpretation or abstraction, not a reality or tangible quantity such as 'cash in the till.' According to accounting practice, it is determined by taking the total income received by an enterprise and deducting the operating expenses and taxes, and then subtracting an *estimate* of the extent to which the capital assets employed have been extinguished; that is, worn out and used up. The sum thus set aside out of the total cash produced is supposed to be sufficient to replace the facilities of the business so that it can continue as a going concern. It is obvious that the adequacy of the sum thus set aside for replacement determines the reality of the reported net income. It is equally clear that 'profits,' depending for their computation on an estimate, are themselves not an absolute quantity.

"There are four basic conditions which should be clearly held in mind by anyone seeking to analyze the size and significance of profits. I shall try to define these four principles and then briefly illustrate each point by data taken from our study of 30 oil companies.

"(1) In times of inflation, or rapid change in the purchasing power of the dollar, 'profits' as reported on the basis of established accounting practice are in effect overstated by the amount of the rise in replacement costs over the sum set aside to cover capital extinguishments — depreciation, depletion, and the like.

"(2) In times of inflation, reported 'profits' cannot properly be compared with previous years because of the shrinkage in the purchasing power of the dollar. Only by correcting for the changing length of the yardstick can this be done with any semblance of accuracy.

"(3) In times of inflation, the rate of return on the capital employed, ordinarily a very useful standard, cannot be used as a criterion of the magnitude of profits because the rate of return is a ratio between two sets of dollars of different values. It is a mathematical error to strike a ratio between things of a different kind. Only by adjusting either the capital employed or else the 'profits' to like dollars is such a ratio permissive.

"(4) In all times, inflationary or normal, the most effective criterion to apply in the judgment of 'profits' is their adequacy or inadequacy in the process of capital formation. Our entire economy is dependent upon the formation of sufficient capital funds to maintain and expand the country's productive capacity. As capital costs rise, 'profits' are called upon to supply increasing amounts of these funds.

"The reported net income of thirty oil companies was $763,000,000 in 1946 and $1,219,000,000 in 1947, an increase of $456,000,000, or 60 per cent. On the face of it, this increase appears large. But the charges for capital extinguishments (depreciation, depletion, etc.), designed to recover the capital funds extinguished during the year, were inadequate to replace the physical counterpart of this capital at prevailing higher costs. 'Profits' were therefore called upon to make up the discrepancy and part of the reported total was diverted to this purpose. Thus 'profits' computed by accounting procedure were larger than *de facto* profits. In other words, the *increased* cost of replacement appeared on the books as a profit."

Better Gasoline

Postwar motor fuels are much superior to the wartime grade, as every motorist has found by experience; they are also better than the prewar quality, and are getting better all the time. This statement refers primarily to the antiknock characteristics, which, to the average motorist, is the best index of quality. The latest Bureau of Mines report, based on samples taken last summer, indicates that the octane rating of first-grade gasoline (known as "ethyl gas") in various sections of the country varied from an average of 77.7 in the central plains area, where they don't have mountains to climb, to 82.1 in the Pacific Northwest, the countrywide average being 79.5. Second-grade (or "regular gas") varied from 72.8 in the South Mountain States to 77.3 in the Mid-Atlantic and New England States, the national average being 75.2 This compares with an average of 75.1 in the summer of 1947 and 74.4 in 1946. The premium grade figure of 79.5 in 1948 compared with 79.2 the previous summer, 78.3 in 1946, and 74.9 in 1945. In other words, the so-called regular grade of gas we are now getting is better than the ethyl grade we were offered in 1945. However, the compression ratio of automobile engines is increasing, which means they must have a gasoline of higher octane rating in order not to knock. If the compression ratio were greatly increased the engines would be much more efficient, but would require a gasoline with an octane rating of something like 100, as do airplane engines, and that would cost enough more to offset the increased efficiency, in whole or in part.

The Bureau's figures do not distinguish between the different brands as to octane ratings, which information would, of course, help motorists in gauging the relative qualities of the various gasolines offered.

If a motor knocks, however, it is not usually necessary to buy a more expensive gasoline to make it run quietly—a simple adjustment in the vacuum line, or an adjustment of the spark may be all that is necessary. In other words, the motor may be adjusted to the gas, as well as the gas selected for the motor.

Better quality of motor fuels and lubricants year by year, as well as a plentiful and comparatively cheap supply compared with many other commodities, is something for which the owners of some 40,000,000 American cars can thank the petroleum industry.

Embarrassing Moment

Nothing recently has been a greater surprise to us than when, in browsing through the March issue, we came to page 74 of the All-Institute Section. This page had been carefully concealed from us until the issue appeared, and the preliminary work had been done during our absence in San Francisco. For seventeen years we have been successful in keeping even our picture out of the paper, and now they do this to us. Immediately after concocting this, Frank Sisco had the good sense to make plans to leave the country, and when that issue reached its readers, he was well on his way to an unknown spot in South America.

ALL INSTITUTE SECTION

APPEARING IN:
- MINING ENGINEERING
- JOURNAL OF METALS
- JOURNAL OF PETROLEUM TECHNOLOGY

New Board Meets for the First Time in San Francisco

Twenty-five of the 36 Directors of the Institute were on hand for the Board meeting held during the Annual Meeting of the Institute in San Francisco, on Tuesday, Feb. 15, immediately following the annual business meeting, when the newly elected officers and Directors took their seats. Of the new group, L. E. Young, William Coulter, Lloyd E. Elkins, James L. Head, Howard A. Meyerhoff, E. R. Price, Frederick N. Rhines, John D. Sullivan, and George P. Swift were present. President Young presided for the first time. Most interest centered on a resolution drawn up by the Section Delegates after extended discussion at two sessions the day before. when they voted, 31 to 6, that the Board should consider raising the dues of Members and Associate Members from $15 to $20, and of Junior Members from $10 to $12, for the next three years, at which time a referendum would be taken as to whether or not the increase should be continued. The hope is that in three years the accumulated deficit of the last two or three years can be wiped out and that advertising income will be sufficient by that time to supplement the income from dues at the present rate so that the budget can be balanced. The Board voted to accept the resolution of the Section Delegates and to take the necessary steps to make an increase in dues for 1950 effective. This will involve a change in the by-laws and a referendum of the voting membership in the United States, Canada, and Mexico. Data to show why the increase is necessary if the present services of the Institute are to be continued or expanded will be supplied to all Institute members before the referendum is taken.

Much interest was also shown in the report of the Committee on Democratization, Joseph L. Gillson, chairman, with George Corless and E. A. Anderson. Dr. Gillson distributed copies of his report to all Directors present, and discussed his findings in some detail. The six principal recommendations were stated in the report of the January Board meeting on p. 137 of Sec. 2 of the March issue of this journal. The Board accepted the report with thanks, with the promise that such of its recommendations as can be financed will be put in force if found desirable by the Directors after study. A report of such study is to be made at the April meeting of the Board, at which time a further report from Dr. Gillson's committee was also invited.

Attention was called to the fact that at its meeting in November 1947 the Board had decided not to issue an AIME Directory in 1949 and that action was approved by the 1949 Board because of the expense that would be involved. The 1948 Directory had cost $14,000, and printing costs have since risen. A list of all officers, committee personnel, and other newly revised matter will be published in Section 2 of the monthly journals during the spring.

Authorization was voted to proceed with a new and completely revised edition of "Coal Preparation" which has recently become out of print. David R. Mitchell will again be the editor and it is hoped that the book can be published before the end of the year. An additional amount of $6000 was also appropriated from the Seeley W. Mudd Fund for the new edition of "Industrial Minerals and Rocks," supplementing the original appropriation of $10,000. Typesetting on the revised book is now well along and the volume should be ready early in the fall. A request that some 2000 copies of the recently published book by Robert E. Hardwicke on the effect of antitrust laws on the unit operation of oil and gas pools be distributed to libraries will be considered further at the March meeting.

Six major awards were authorized for presentation at the Annual Meeting in 1950 if the respective committees can agree on candidates. They are the Rand, Saunders, Douglas, Lucas, and Ramsay medals, and the Richards award. The committee will

Attendance at Meeting of Directors, February 15, 1949

Directors

L. E. YOUNG, President, who presided

Newell G. Alford
C. H. Benedict
Arthur J. Blair
Oliver Bowles
William E. Brewster
William J. Coulter
Erle V. Daveler
Lloyd E. Elkins
J. B. Haffner
James L. Head
Philip Kraft
William Wallace Mein, Sr.
Howard A. Meyerhoff
C. V. Millikan
E. R. Price
Frederick N. Rhines
E. E. Schumacher
John D. Sullivan
George P. Swift
R. W. Thomas
C. P. Watson
C. E. Weed
Curtis L. Wilson
W. E. Wrather

David C. Minton, Jr., alternate for Clyde Williams
Benton F. Murphy, alternate for Andrew Fletcher

Staff and Guests

D. W. Akins, Jr.
Joe B. Alford
R. H. Allen
Kenneth H. Anderson
Paul Andrews
S. S. Arentz, Jr.
Clayton G. Ball
R. J. Bethancourt
Stuart E. Buckley
H. M. Cooley
L. F. Elkins
G. H. Enzian
Norman D. Fitz-Gerald
P. E. Fitzgerald
Herbert A. Franke
O. B. J. Fraser
Thomas C. Frick
C. Y. Garber
Joseph L. Gillson
M. L. Haider
J. P. Hammond
Ray A. Hancock
Don L. Harlan
P. D. I. Honeyman
Elmer R. Kaiser
E. J. Kennedy, Jr.
Harold A. Krueger
J. C. Landenberger, Jr.
Carleton C. Long
William Wallace Mein, Jr.
Bennie G. Messer
V. J. Mercier
Harvey S. Mudd
Henry T. Mudd
W. A. Mueller
John F. Myers
F. M. Nelson
Russell B. Paul
H. S. Peterson
L. F. Reinartz
Edward H. Robie
H. A. Sawin
Dean H. Sheldon
A. A. Smith, Jr.
Joe P. Smith
Richard W. Smith
W. A. Sterling
W. R. Storms
William H. Strang
Landon F. Strobel
Linwood Thiessen
F. E. Van Voris
H. Y. Walker

welcome suggestions as to the names of men deserving the honors.

Chairmen of certain new standing committees of the Institute were named, the complete list to be announced at the March meeting.

Dates for the next four meetings of the Board of Directors were set as follows, each date falling on a Wednesday: March 16, April 20, May 18, and June 15.

At the request of Dr. Rhines, consideration was given to the proposal that a publication manager, or advertising manager, be secured to promote advertising in the new journals, as suggested by the Johnson Committee. Discussion at some length is planned for the March meeting of the Board and in the meantime Mr. Schumacher, with two other committee members to be selected by him, will study the advertising situation in respect to the *Journal of Metals*.

An Affiliated Student Society, comprising a group of students majoring in geology at the University of Wichita, was recognized. J. R. Berg is Faculty Sponsor and Edward A. Koester, Counselor.

The open meeting of the Board was preceded by an executive session at which the personnel of the Executive and Finance Committees for the coming year were named as follows:

Executive Committee

L. E. Young, chairman
Donald H. McLaughlin, vice-chairman
A. B. Kinzel
Earle E. Schumacher
John R. Suman

Finance Committee

Erle V. Daveler, chairman
Philip Kraft
Clyde E. Weed

Andrew Fletcher was unanimously re-elected Treasurer for the ensuing year, and Edward H. Robie, who had been Acting Secretary since Sept. 1 last, was elected Secretary.

Among the Student Associates

City College of New York

The Student Chapter at CCNY met on Jan. 14 to fill the offices left vacant by graduations. Herbert Feely is the new President; Jack Tarr became Vice-President; Julius Jettelson was named Secretary; and Seymour Feerst is Treasurer.—*Herbert Feely, President.*

University of Nevada

The Crucible Club of the Mackay School of Mines ended the year 1948 with publication of their semi-annual "Mackay Miner", and two interesting sessions with prominent guest speakers. Don White, Bureau of Mines geologist, spoke on Dec. 3, illustrating his topic "Volcanoes, Hotsprings and Ore Deposits" with slides. W. H. Denning, of the United Geophysical Co., was the year's final speaker, accenting new geophysical methods of finding oil in Brazil, and emphasizing the opportunities in geophysics which await young graduates.

The Club requests former students and graduates to forward their current addresses for the "Mackay Miner" mailing list.—*William D. Williams, Secretary.*

Illinois Institute of Technology

Forty-five members of the Illinois Institute of Technology Chapter of AIME have just completed their first, and highly successful semester at the school. Under the aegis of President Edward Murway, a weekly program of movies and guest speakers was followed, and the Chapter also managed to find time to put a basketball and volleyball team into intramural competition.

Edward Lever, Vice-President; Robert Domagla, Secretary; and Treasurer John Cordes, will hold down those positions, along with President Edward Murway, until June elections. T. S. Washburn, of Inland Steel, is the Chapter's Counselor. Both he and H. M. St. John, of the Crane Co., have addressed the Tech Chapter. Otto Zmeskal and Lucio Mondolfo are Faculty Sponsors.—*Robert Domagla, Secretary.*

Oregon State College

The Student Chapter at Oregon State College was reactivated in January, and new officers were elected at an informal meeting. Ronald F. Robberson will henceforth wield the gavel, and James G. Osborne, Jr., is Secretary. Dr. Ira S. Allison remains as Faculty Sponsor.

The Chapter's new Counselor, F. W. Libbey, director of Oregon's Department of Geology and Mineral Industries, who spoke at the group's first formal meeting, found many interested listeners to his talk on bauxite occurrences in northwestern Oregon.—*James G. Osborne, Jr., Secretary.*

What Went on at Recent Local Section Meetings

SECTION	DATE	PLACE	PRESIDING OFFICER	ATTENDANCE	SPEAKER, AFFILIATION, AND SUBJECT
Arizona, Ajo Subsection	Feb. 2	Ajo	William Keener	23	Jack Sheridan, Chile Copper Co., on Mining at Chiquicamata.
Boston	Feb. 7	Smith House, Cambridge	George P. Swift	65	J. N. Hobstetter, Harvard Univ., on Diffusion in Metals.
Carlsbad Potash	Feb. 17	Carlsbad	G. E. Atwood	58	John A. Frost, USGS, "Down the Colorado With Homemade Boat & Kodachrome."
Chicago	Feb. 2	Chicago	T. S. Washburn	123	S. J. Creswell, Carnegie-Illinois Steel Corp., on Recent Developments of the Bessemer Process.
Cleveland	Jan. 13	University Club	John M. Kiefer		Carl F. Frutton, Lubrizol Corp., on Lubrication and Lubricant Research.
Columbia	Feb. 4	Davenport Hotel, Spokane	Howard Sherman	28	Eugene Roberts, Merrill, Lynch, Pierce, Fenner and Beane, on Money at Work.
Connecticut	Feb. 9	Waterbury	R. S. French	40	R. D. Heidenreich, Bell Telephone Laboratories, on Electron Microscopy and Electron Diffraction.
Delta, Mississippi Subsection	Jan. 28	Jackson, Miss.	W. W. Ramseur	55	H. G. Dewey, Jr., Chief, Miss. Basin Branch, Waterways Experiment Station, on The Waterways Experiment Station.
El Paso Metals	Feb. 9	Hotel Cortez, El Paso	Edward M. Tittman	39	W. D. Sydnor, Jr., Guided Missile Dept., Fort Bliss, Texas, on The Principle of Jet Propulsion.
Kansas	Feb. 9	Great Bend, Kans.	V. J. Mercier	85	Roscoe Clark, Stanolind Oil & Gas Co., on Proper Cementing of Casing.
Mid-Continent	Feb. 14	Tulsa, Okla.	John P. Hammond	62	Jack Webber, Atlantic Refining Co., on Hydraulics in the Use of Oil Well Packers.
North Pacific	Jan. 20	University of Washington	Kenneth H. Anderson	95	Ralph A. Sherman, Assistant Director, Battelle Institute, on Fuels for Today and Tomorrow.
Southeast, Florida Subsection	Nov. 1	Bartow, Fla.	E. S. Beebe		W. H. Twenhofel, Emeritus Professor, Univ. of Wisconsin, on Sedimentation. Dr. Rodgers, Stanford Univ.
Southeast	Jan. 19	Molton Hotel, Birmingham	J. C. Gray	30	P. O. Powers, Battelle Institute, on Plastics as Applied to Mining, Metallurgy and Coal.
Southwest Texas	Feb. 9	Corpus Christi	Raoul J. Bethancourt	277	M. M. Kinley, M. M. Kinley Co., talk and films on Oil Well Fires and Blowouts.
St. Louis	Dec. 10	York Hotel			S. S. Clarke, General Superintendent of Mines, Eagle-Picher Co., on Underground Mechanization in the Tri-State District.

Colorado School of Mines

A review of the last fifty years in the coal mining industry was presented by Thomas Allen, Colorado State coal mine inspector, at the Jan. 13 meeting of the Student Chapter at Colorado's School of Mines. Mr. Allen enlivened his speech on past and present mining methods, labor relations and government control with personal anecdotes drawn from his own experiences.

At the Feb. 10 meeting, President Herman Knight introduced Alfred Crofts, of Denver University's history department, who spoke of the young engineer's responsibility and future in a world of changing foreign and domestic social conditions. A question and answer period followed Dr. Knight's talk.—*Harvey W. Smith, Public Relations Chairman.*

University of Idaho

The Associated Miners of the University of Idaho were regaled at a banquet on Jan. 6. Eighty assembled members and guests were addressed, and saw movies shown by petroleum geologist John B. Miller, who heads the photogrammetric division of an American oil company in Colombia. His films portrayed native life, agriculture, industry, geology, and geography of the South American nation. —*A. G. Randall, Secretary-Treasurer.*

Missouri School of Mines

A record-breaking crowd of 243 men turned out for the Feb. 10 meeting to view two interesting movies and enjoy the usual refreshments. The first movie, "Lead Smelting at the St. Joseph Lead Co.," pictured all the steps in changing ore to lead, both in milling and smelting. The second, "The Army-Navy Football Game" was highly entertaining, and perhaps even educational. This Chapter is looking forward to breaking their new attendance record within a short time. —*Albert A. Jones, Secretary.*

South Dakota School of Mines

Not even a blizzard could stop Drill and Crucible Club members from gathering on Jan. 27 to hear Al Needham, of the Bureau of Mines, speak on reverse core drilling and present his own movies of the process. Also on the agenda for that night was the general superintendent of the Braden Mines in Chile, who gave a highly informative talk on block caving methods.

At the Club's Dec. 7 meeting, three movies were shown, all highly recommended to other Chapters. They were: The Story of Copper, Nickel Milling and Smelting, and one about the Homestake Gold Mine at Lead, S. D. The first two were provided by the Bureau of Mines Graphic Services Section in Pittsburgh. The above mentioned blizzard didn't even dent the Club's new attendance records, which have so far doubled last year's average of 35 at each meeting.—*Russell J. Gamberg, Secretary.*

News of AIME Members

John E. Bowenkamp

Charles S. T. Farish

Henry M. McLeod, Jr.

John E. Bowenkamp returned to Colombia in February after a combined vacation, leave of absence, and business trip to the United States and Canada. Now that he is back in Medellin he will continue to carry on in his capacity of mine examination engineer for Wellington Explorations Ltd., a subsidiary organization of the N. A. Timmins Corp. of Montreal. His airmail address is Apartado Aereo 817, Medellin.

William H. Bradbury graduated from the University of Colorado last August with a B.S. degree in chemical engineering and is now employed as an assayer for the Cia. Minera del Mexcala, Gro., Mexico.

John B. Breymann, III, after finishing his studies at MIT, is working for the Shenandoah-Dives Mining Co., Silverton, Colo.

Frank Cameron is working for the Saudi Arabian Mining Syndicate, Jeddah, Saudi Arabia. He had been living in Jenkintown, Pa.

J. A. Caverly, now with the Gardner-Denver Co., Quincy, Ill., used to work at the Snow Lake division of the Howe Sound Exploration Co., Snow Lake, Man.

A. J. Cayia has been elected president of the Inland Lime and Stone Co. He has been with the Company since 1928, and was formerly a mechanical engineer for the M. A. Hanna Co.

Charles S. T. Farish has been promoted to general superintendent of mines of the Cerro de Pasco Copper Corp. at La Oroya, Peru. He has been with Cerro since 1919 as mine engineer, general mine foreman, tunnel foreman, assistant superintendent, and superintendent.

L. M. Abell left Fiji, where he was with the Emperor Gold Mining Co., Vatukoula, last November, spent a few weeks in Canada and the States and then went on to Skouriotissa, Nicosia, Cyprus, where he is mill superintendent for the Cyprus Mines Corp.

Bert C. Austin, president of Bert C. Austin & Co., of San Francisco, is doing the consulting engineering work on the Vivian Mining Co.'s recently leased Pine Hill mine, in the Wolf district, southwest of Grass Valley, Calif.

Richard C. Badger, vice-president of Park City Cons. Mines Co., is directing the rehabilitation operations at the Company's Park City, Utah, property which had been shut down for five years.

Daniel F. Flowers is engineer for the Differential Steel Car Co., Findlay, Ohio, and gets his mail at 1109 S. Main St., Findlay.

Donald W. Frommer has established a permanent address at 16 Great Oaks, Rolla, Mo. Since last August he has been employed by the Rolla station of the Bureau of Mines, working on flotation and other types of mineral dressing.

Henry M. McLeod, Jr., who for the past three years was a project leader in T.V.A.'s process development division at Wilson Dam, Ala., has accepted a job with the research and development division of the Carbide and Chemicals Corp., at Oak Ridge, Tenn. His address is 110 Porter Rd., Oak Ridge.

Louis C. Ball has been appointed geologist of the Standard Gypsum Co. with headquarters in the Kaiser Bldg., Oakland, Calif. He worked for the Aluminum Co. of America before serving as a naval officer for two years during the war, seeing action during the Okinawa campaign and the subsequent minesweeping in Japanese waters. In 1946 he joined another Henry J. Kaiser operated company, the Permanente Metals Corp., and was engaged in the exploration of bauxite land under option in Surinam, Dutch Guiana.

Edward G. Fox, who has been president of the Shen-Penn Production Co., has become general manager of the Philadelphia and Reading Coal and Iron Co., Pottsville, Pa.

H. S. Fowler left his post as general superintendent of the Blubber Bay plant of the Pacific Lime Co. early in October to join the engineering staff of the Denver Equipment Co., Denver, Colo.

Percy Gardner, Jr., has the job of engineer with the Silver Dollar Mining Co. at Wallace, Idaho.

William D. Leonard, of 4416 View St., Oakland 11, Calif., is manager of the Emprise Sales Co.

David E. Morgan

David E. Morgan is traveling in European and African mining territories, representing various American mining equipment manufacturers and is also acting as a consulting engineer for foreign mining companies. He can be reached through his New York City office at 220 Broadway.

Ronald K. Sorem has taken the job of geologist with the U. S. Geological Survey in Washington, D. C.

Robert L. Swain is employed in Kimberly, Nev., as an underground engineer for the Consolidated Coppermines Corp. His mailing address is Box 206, Kimberly.

Glen C. Taylor has moved to Evans, Wash., where he is employed by the U. S. Gypsum Co. as a plant engineer.

Robert E. Thurmond is in Jerome, Ariz., where his mail is received at Box 1423, and his job is geophysical field engineer for the Newmont Mining Corp.

Frank E. Tippie can be reached in care of Cia. Minera y Refinadora Mexicana, Estacion Wadley, S. L. P., Mexico. He had been with Patino Mines and Enterprises Consolidated in Bolivia.

Theodore Toren, Jr., formerly with Day Mines, Inc., Wallace, Idaho, is employed by the Oliver Iron Mines in Hibbing, Minn. His new address is 1029 W. 29th St., Grand Rapids, Minn.

Abner A. Towers has been transferred from the New York office of the Dorr Co. to the Atlanta office. His new address is 2421 Sagamore Dr., Atlanta N. W., Ga.

N. de Voogd is general manager of Metalurgia Jofremars, Caixa Postal 38, São João del Rey, Minas Gerais, Brazil. Since October he has been in charge of operations at three properties of the Company, all situated in the São João del Rey tin belt, where he hopes to develop vein and placer mining and a small smelter.

H. A. Waite left Salt Lake City the end of December to go to Honduras as general superintendent of the New Idria Honduras Mining Co., Santa Rosa de Copan, Honduras.

Arnold H. Walker, formerly with Sladen Malartic Mines Ltd., is now working for Barnat Mines Ltd., Box 33, Malartic, Que.

Joseph J. Wallace, formerly a student-trainee with the Pittsburgh Coal Co., has joined the staff of the Bureau of Mines at Pittsburgh as a mining engineer.

Robert H. Wheless, who had been a student at the University of Alabama, is working at the Praco mine of the Alabama By-Prod Corp., Praco, Ala.

Harold H. White

Harold H. White severed a twenty-year connection with the Atlas Powder Co. on Feb. 1, to take charge of a newly formed consulting engineering company composed of Texas engineers and scientists. Chief company operations will be the control of blasting in settled areas, and measurement of blast vibrations. Mr. White was instrumental in the formation of Atlas's subsidiary company in Mexico, and directed its operations until 1947. His new firm's headquarters will be in Houston, with branches in New York, Chicago, and Cleveland, rounding out the nation-wide scope of operations.

T. A. Woods-Smith has moved from Los Angeles, and is now associated with Patiño Mines and Enterprises Consolidated, Siglo XX, Llallagua, Bolivia.

Dan S. Young, former chief engineer and geologist for the Castile Mining Co., has gone to Montreal, Wis., where he is associated with Oglebay Norton and Co.

• In Petroleum Circles

Forrest J. Allen, Jr., graduated from the University of Oklahoma in January and has gone to work for the California Co., 1818 Canal Bldg., New Orleans 12, La.

Donald L. Bohannan has moved to Wyoming with the Stanolind Oil and Gas Co. His address is P. O. Box 966, Midwest, Wyo.

Ira H. Cram has changed his address for mail from the Pure Oil Co. of Chicago to the Continental Oil Co., Ponca City, Okla., being a vice-president of the latter company.

Jack D. Duren is working for the Shell Oil Co. as a junior exploitation engineer. Mail reaches him at 521 E. First St., Trinidad, Colo.

Patrick N. Glover, exploitation engineer for the Shell Oil Co. at Los Angeles, lives at 829 S. Bundy Dr., Los Angeles 24, Calif.

Wilber H. Griffin, who was with Baker Oil Tools, is general sales manager for CAMCO, Inc., manufacturers and distributors of Camco gas lift equipment, in Houston. His permanent address is 1601 S. Shepherd Drive, River Oaks Gardens, Houston 19.

David P. Hoover has been working on a trainee program sponsored by the Gulf Oil Corp. with an address at 506 LaFayette, Pittsburg, Texas.

Alden J. Laborde, whose last address was in New Orleans, is now marine superintendent with Kerr-McGee Oil Industries, Morgan City, La.

Billy B. Lane is working as a field engineer for the Sohio Petroleum Co. at Eureka, Kans.

Philip Maverick, Jr., is a petroleum reservoir engineer with the Phillips Petroleum Co., 219 S. Big Spring St., Midland, Texas.

Neal McCaskill has returned from Venezuela, where he was working as a petroleum engineer with the Venezuela Atlantic Refining Co., and can now be reached at 1708 16th Street, Lubbock, Texas.

Paul M. McMinn, formerly at the University of Wisconsin, has moved to Denver, Colo., to work for the California Co.

Roderick G. Murchison resigned from the Socony-Vacuum Oil Co. of Colombia in March 1948 and since that time has been instructor in geology at the University of North Carolina, Chapel

Hill. His permanent address remains P. O. Box 547, Rocky Mount, N. C.

F. Ward O'Malley has joined the exploration department of the Continental Oil Co. and is working at the Denver office, Rm. 1029, Continental Oil Bldg.

E. R. Osburn is reached now in care of the Union Producing Co., P. O. Box 1422, Monroe, La.

Harold E. Parsons transferred on Jan. 20 from Lima, Peru, where he has been for almost four years, back to Bogota, Colombia, still with the same employers, Socony-Vaccum Oil Co. His work in Bogota will be much the same as he was doing in Peru, where he was working on photo-geological mapping, with several extended field trips in the montaña—the jungle lowlands east of the Andes in the region of the upper Amazon drainage. He expects to return to the States on leave some time this summer. His address is Apartado Nacional 1140, Bogota, Colombia.

L. F. Peterson has terminated several years service with the Stanolind Oil and Gas Co., to join as a partner in the Midland, Texas, consulting firm of Henderson, McMillian and Peterson. The firm will handle petroleum geological and engineering problems, property management, leasing, title examination, and well completions.

Darrell S. Pierson, no longer a student at the University of Utah, is employed by The Texas Co. producing department at Sunburst, Mont., as a petroleum engineer-trainee.

Floyd W. Preston is now a research engineer with the California Research Corp., a Standard Oil Co. of California subsidiary, at La Habra, Calif. He joined the Company recently, after receiving his M.S.E. degree from the University of Michigan.

Claude O. Stephens is now in Worland, Wyo., working for the Texas Gulf Sulphur Co. His address there is P. O. Box 15.

Arthur G. Sullivan, Jr., no longer a student at Texas A&M, is a junior petroleum engineer with the Ohio Oil Co., with a new address at 121½ Old Kilgore Highway, Henderson, Texas.

Robert P. Thomas is now employed as a junior seismologist in training with the Shell Oil Co. He expected to receive his M. A. degree from the University of California in February.

William H. Wadlington, having finished his studies at Texas A&M, is a junior petroleum engineer with the Stanolind Oil and Gas Co., Box 1518, Levelland, Texas.

Arthur L. Jenke

Arthur L. Jenke is now in Abilene, Texas, where he is associated with Riley Maxwell, consulting geologist. Mr. Jenke's chief interest is in the operation of a core testing laboratory which he set up several months ago in the West Texas city. Prior to his venture into the consulting field, he attended Washington University in St. Louis, receiving a M. S. degree in geology last June. During the academic year 1947-1948 he held a Shell Oil Co. fellowship in geology. A tenure of approximately seven years with the U. S. Geological Survey was brought to a close with his resignation last May.

Karl L. Wehmeyer, Jr., has been appointed resident geologist of the Mene Grande Oil Company's Bolivar coastal fields. His address is Geological Dept., Apartado 234, Maracaibo, Venezuela.

Norman Wilson is district geologist for the Great Lakes Carbon Corp., 417 Indiana Bank Bldg., Evansville, Ind.

• In the Metals Divisions

Donald H. Beilstein has the job of junior metallurgist in the Federated Metals division of the AS&R Co. in San Francisco. His home address is 272 Everett Ave., Palo Alto, Calif.

William W. Berkey is working for the Kaiser-Frazer Corp. at Willow Run, Mich., as a metallurgist.

Jay R. Burns is now employed as a research engineer in the process development department, magnesium division of the Dow Chemical Co. He had been chief of the magnesium unit, materials laboratory, Wright-Patterson Air Force Base.

John M. Crockett is assistant metallurgical engineer with the Air Reduction Sales Co., New York City. His mail goes to 23 Bounty St., Metuchen, N. J.

Edmund C. Franz is in Cleveland, Ohio, now, working for the Aluminum Co. of America, 2210 Harvard Ave.

Emerson L. George is a junior engineer for McConway Torley Inc. of Pittsburgh. His home address is 219 Oakland Ave., Apt. 31, Pittsburgh 13.

Russell G. Hardy has moved from Baltimore, Md., where he was with the Gibson & Kirk Co., to Chicago to work for the Argonne National Laboratories. His address is 1550 E. 61 St., Chicago.

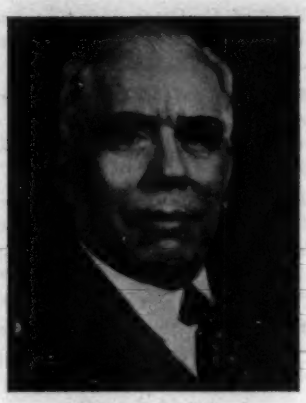
Frederick A. Hartgen is sales manager and metallurgist for Nutmeg Crucible Steel, Branford, Conn.

Alexander L. Feild

Alexander L. Feild, associate director of research for the Armco Steel Corp., was awarded an honorary degree of Doctor of Science on Feb. 5 by the Stevens Institute of Technology, Hoboken, N. J. A Tarheel by birth and education, with degrees from the University of North Carolina and from N. C. State College, he has worked for his state agricultural department and for the U. S. Bureau of Mines. For the last thirty years he has been a research man in industry, during which time 28 U. S. patents have been awarded to him.

David W. Pettigrew, Jr., who graduated from the Carnegie Institute of Technology last June with a B.S. degree in metallurgy, has returned to the Aluminum research laboratories of the Aluminum Co. of America, New Kensington, Pa., where he is employed as a research engineer in metallography.

Morris Steinberg, of the metallurgical division of Horizons Incorporated, has ben appointed head of the division. Dr. Steinberg received his doctorate from MIT in June, 1948, and joined the staff of Horizons at that time. He is co-author of "Lead-grid Study of Metal Powder Compaction" presented at the Annual Meeting in San Francisco in February.



Robert C. Stanley

John F. Thompson

Paul D. Merica

Robert C. Stanley, president since 1922, director since 1917, and chairman and president since 1937 of the International Nickel Co. of Canada, continues as chairman of the board, while **John F. Thompson**, who has been an executive vice-president since 1936 and a director and member of the executive committee since 1931, has become president. **Paul D. Merica**, vice-president since 1936 and a director, is now executive vice-president. Under Mr. Stanley's chairmanship, International Nickel has become the world's largest producer of nickel and platinum metals and the largest copper producer in the British Empire. Recently he resigned as chairman of the trustees of Stevens Institute of Technology, after serving for twelve years. Dr. Thompson joined the Company as a metallurgist in 1906, becoming manager of operations in 1921 and assistant to the president seven years later. He supervised the construction and initial operations of the Company's Huntington, W. Va., works, founded for the production of nonferrous alloys. For many years the Company's production in the States and its operations and markets in Great Britain and Europe have been among the matters in his particular charge. Dr. Merica has been with International Nickel since 1919, becoming director of research and later associate manager of the development and research department. In addition to his responsibilities as vice-president, he has continued to give special attention to the Company's research activities in Canada, the United Kingdom, and the States. He has evolved numerous iron-nickel and copper-nickel alloys and is the author of many technical papers and articles.

Donald D. Helman is working for the Ohio Steel Foundry Co., Springfield, Ohio, as a metallurgist.

Harry Hey has been made managing director of the Electrolytic Zinc Co. of Australasia, Melbourne, Australia.

Norton Jackson has left the Emperor Gold Mining Co., Vatukoula, Fiji Islands, to become metallurgical engineer for the Department of Mines, South Australia. His new address is 64 Tusmore Ave., Tusmore, S. Australia.

S. T. Jazwinski, vice-president of the Detroit Steel Casting Co., Detroit 10, Mich., has gone to Rio de Janeiro for several months.

Bruce S. Old

Bruce S. Old has been elected to the board of directors of Arthur D. Little, Inc., research and engineering organization. Dr. Old joined the concern in 1946 after leaving the Navy, where he served in the Office of Research and Invention with the rank of Commander. He is now in charge of process metallurgy for Arthur D. Little as well as consultant to the Office of Naval Research and the Atomic Energy Commission, in the latter as chief of metallurgy and materials branch, Division of Research.

Peter J. Kassak, Jr., former University of Pennsylvania student, is now a cadet engineer with the Public Service Electric and Gas Co. of Newark, N. J. His address is 729 Colonial Ave., Union, N. J.

John R. Kunkel has left the Fansteel Metallurgical Corp. to work at the Ingersoll steel and disc division of the Borg-Warner Corp., Chicago. His mail is sent to 12409 S. Ada St., Chicago 43.

LeRoy H. Markway is working for the Shell Oil Co. at Wood River, Ill., as a junior engineer.

Raymond L. McGaughey graduated from the University of Illinois last summer with a degree of B. S. in metallurgical engineering. At present he is employed by the Elgin National Watch Co. as a research metallurgist. His mail goes to 1191 Logan, Elgin, Ill.

Whitney P. Mee has been retained as consulting metallurgist by Cia. Metalurgica Peñoles, a subsidiary of the American Metals Co. since August 1947. Most of his time has been spent at the Peñoles lead-copper smelter at Torreon, Coah., with periodic trips to the company's headquarters at Monterrey, N. L. Upon completion of an extensive construction program late this year, the capacity of this plant will have been practically doubled, and many improvements are being made which will make the Torreon smelter one of the most modern and efficient in Mexico. **Philip Doerr** is manager of the plant and **I. M. Symonds** is in charge of operations.

Wilbur L. Mudge, Jr., has taken the job of metallurgist with the Foote Mineral Co. of Philadelphia, and is continuing his graduate studies at the University of Pennsylvania. His address is 2840 Washington Ave., Apt. C, Camden, N. J.

Omaha Public Library
Reference Dept.

Edward C. Nelson, former assistant metallurgist at the Naval Research Laboratory, Anacostia Station, Washington, D C., has joined the staff of Rensselaer Polytechnic Institute, Troy, N. Y., as an instructor in metallurgical engineering.

Robert M. Parke, who has been at the applied physics laboratory of Johns Hopkins University, is acting as technical adviser for Battelle Memorial Institute, Columbus, Ohio.

T. W. Plante, superintendent of blast furnaces for the Jones & Laughlin Steel Corporation's Eliza works in Pittsburgh, will go to Chile in the spring to be superintendent in charge of blast furnaces and raw materials for the Pacific Steel Co. of Chile. He will be in Pacific Steel's New York offices for a while and then make his home in Concepcion, where the Company is now building an integrated steel mill.

Kenneth L. Quigley is associated with Northern Ordnance Inc., Columbia Heights Station, Minneapolis, Minn. He was with the Champion Motors Co.

Edward J. Ramaley has accepted the post of tool design research engineer with the Lockheed Aircraft Corp., Burbank, Calif.

Fred Romano, former research metallurgist for the National Smelting Co., has taken over as superintendent of plant metallurgy for the Monarch Aluminum Mfg. Co., Cleveland, Ohio.

Carl H. Samans recently resigned as chief, metallurgy section, research laboratory, American Optical Co., Southbridge, Mass., and can be reached at the Engineering Research Dept., Standard Oil Co. (Indiana), 910 S. Michigan Ave., Chicago 80.

Eraldus Scala, who became a Student Associate in 1947 while attending Columbia University, is now employed in the research laboratory of Chase Brass & Copper in Waterbury, Conn. His new address is 31 Chipman St., Waterbury.

J. R. Scrivener, sales engineer with the Permanente Products Co., has transferred from the Chicago office to the Company office at 1924 Broadway, Oakland 12, Calif.

Tryggve Smedsland, native of Norway who attended the Missouri School of Mines, and joined the Institute last year as a Student Associate, is now back in his homeland, teaching at the Norwegian Institute of Technology in Trondheim. Members who would like to correspond with their Norwegian co-worker can reach him at the Department of Metallurgy, Norges Tekniske Högskole, Trondheim.

N. S. Spence recently was appointed director of research and development for Dominion Magnesium Ltd., Haley, Ont.

Frank T. Sisco

Frank T. Sisco, director of Alloys of Iron Research, was appointed technical director of the Engineering Foundation, effective March 1. The Foundation, joint research agency of the AIEE, AIME, ASCE, and ASME, sponsors and supports fundamental research in all fields of engineering. Mr. Sisco has worked in the operating departments of various steel companies and as chief of the metallurgical laboratory of the U. S. Army Air Corps at Wright Field, Dayton, Ohio. He has been in charge of Alloys of Iron Research since 1930 and for the present will continue this project.

David T. Steele has taken a job with the American Metal Co., 1 N. La Salle St., Chicago 2. He was with the Duquesne Smelting Corp., Pittsburgh.

P. L. Steffenson, former superintendent of the concentrator plant of the Bethlehem Steel Co., is manager of the Company's raw materials research, Lebanon, Pa.

R. J. Turney has been transferred from the Tacoma plant to the Selby plant of the American Smelting and Refining Co., 405 Montgomery St., San Francisco.

Joseph J. Warga, who was with the Owens-Illinois Glass Co., is now working for the Sperry Gyroscope Co., Great Neck, L. I., N. Y., on process and materials standards.

Harold K. Work became director of the research division of the College of Engineering of New York University on Feb. 1. He was manager of the research and development division of the Jones & Laughlin Steel Corp. Dr. Work is Vice-Chairman of the Institute's Iron and Steel Division.

Obituaries

James S. Douglas

AN APPRECIATION BY R. D. LEISK

James S. Douglas, "miner and banker," as he chose to be listed in the directory of the AIME, died at the age of eighty at his home in Montreal on Jan. 2. His passing marked the end of a notable career that left an indelible imprint upon the history of copper mining in the southwest.

He was born in Quebec in 1868. His illustrious father, James Douglas, was at the time engaged in the development of a chemical process for the treatment of copper ores, an activity which in 1875 necessitated moving from Quebec to Phoenixville, Pa., where James S. Douglas spent much of his boyhood. Dr. Douglas soon began to devote more and more of his time to the investigation of mining properties in the west and southwest and this resulted in an association with the late W. E. Dodge and D. Willis James that brought the old metal trading firm of Phelps Dodge and Co. into the copper mining business at Bisbee and culminated in the formation of the present Phelps Dodge Corp. of which Dr. Douglas was the first president.

With this background, James S. Douglas as a young man developed a keen interest in the growing mining industry of the southwest together with its requirements of rail transportation and finance. He investigated and operated a number of the early mining properties in Arizona and northern Mexico and later engaged in banking and other business. He was perhaps best known for his part in the discovery of the copper bonanza of the United Verde Extension in 1915 at Jerome, Ariz. Here with the help of an associate, the late George E. Tener, he took the lead in reorganizing and backing a venture started by L. E. Whicher. The UVX, as it was called, was a long-shot geological gamble of no small proportions, involving the exploration of faulted Pre-Cambrian formations covered by some 800 ft. of sedimentaries and lavas. Under the direction of Jimmy

Necrology

Date Elected	Name	Date of Death
1940	Elwood Backman	Dec. 16, 1948
1936	Arthur J. Bosse	Unknown
1920	Charles E. Bruff	Feb. 25, 1949
1942	Mark C. Carhart	March 6, 1949
1918	Howard Drullard	Jan. 29, 1949
1916	Horace S. Gulick	Jan. 31, 1949
1938	Philip H. Holdsworth	Nov. 21, 1948
1932	Donald R. Knowlton	March 9, 1949
1935	Otto G. Leichliter	Sept. 8, 1949
1930	R. John Lemmon	Jan. 26, 1949
1916	Walter B. Miller	Sept., 1948
1936	Arthur S. Nichols	Feb. 18, 1949
1913	Walter V. Rohlfs	Unknown
1940	William A. Rose	Jan. 30, 1949
1945	James W. Starks	Feb. 3, 1949
1904	David Rhys Thomas	March 4, 1949
1892	Bailey Willis	Feb. 19, 1949
1916	Harold E. Willsen	Unknown

Douglas, a new shaft was sunk and after many disappointments and the expenditure of much money the venture became a sudden and astounding success when a crosscut on the 1400 level penetrated what was probably the greatest body of high-grade chalcocite ore ever discovered. For three solid years thereafter the ore produced by this great mine averaged 23 percent copper and by the time the ores were exhausted in 1937 the shareholders had received over $50,000,000 in distributions. James S. Douglas served as president of the United Verde Extension Mining Co. until it was dissolved in 1939.

During the first World War he spent much of his time and personal funds in Red Cross work in France where he came to know and admire the wartime Prime Minister, Georges Clemenceau, after whom the UVX smelter town was later named. He wore the ribbon of a Chevalier of the Legion of Honor and for many years it was his custom to spend a month or two each year in France among the simple surroundings he loved so well.

Jimmy Douglas was by nature an aggressive individualist of the old school that contributed so much to the building of the West. He believed in simple and wholesome living and abhorred waste and extravagance. A shrewd trader, uncompromisingly honest in his dealings, he did business on the theory that a man's word should be as good as his bond and that a written contract was no better than the integrity of the signer. He was a man of high character and ideals, and while his approach to the solution of economic and business problems was characteristically simple and direct, he would not compromise principle for the sake of an easy solution. He appreciated art and good music and loved animals, especially the horses which had carried him over so many miles of mountain and desert in his younger days, and the little Arizona quail which came to look for crumbs at the doorstep of his house at Jerome. Well read, a deep thinker and good conversationalist, his opinions were his own and vigorously expounded, but he was nevertheless fair minded and respected the opinions of others so that an argument with him was a stimulating experience that always ended with increased mutual respect. He was a staunch and loyal friend as many who knew him came to realize in time of adversity. As a host he was charming, a courtly gentleman, and ever a good companion.

The memories of many pleasant visits with him at Jerome and at Douglas, Ariz., at the old family home at Spuyten Duyvil on the Hudson, and at Montreal and St. Pierre les Becquets, all carry with them the deep appreciation of having known James S. Douglas.

Proposed for Membership

Total AIME membership on February 28, 1949, was 15,326; in addition 3884 Student Associates were enrolled.

ADMISSIONS COMMITTEE

James L. Head, Chairman; Albert J. Phillips, Vice-Chairman; George B. Coriess, T. B. Counselman, Ivan A. Given, George C. Heikes, Richard D. Mollison, and Philip D. Wilson.

Institute members are urged to review this list as soon as the issue is received and immediately to wire the Secretary's office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

In the following list C/S means change of status: R, reinstatement; M, Member; J, Junior Member; AM, Associate Member; S, Student Associate; F, Junior Foreign Affiliate.

ARIZONA

Ajo—LEWIS, EVAN GERRIT. (R—M). Mill superintendent, New Cornelia branch, Phelps Dodge Corp.

Benson—TOWLE, LOUIS WALLACE. (M). Technical service supervisor, Apache Powder Co.

Superior—NOBS, KENNETH ASTREDO. (C/S—J-M). Level boss, Magma Co.

CALIFORNIA

Alhambra—FATT, IRVING. (J). Associate research chemist, California Research Corp. MUEHL, WALLACE WILLIAM. (M). Sales engineer, Link Belt Co.

Balboa—PYLES, ERNEST E. (AM). Assistant to executive vice-president and general manager, Jergins Oil Co.

Berkeley—GORDON, GEORGE MALVEN. (C/S—J-M). Spectrographer, University of California.

Concord—RHODES, LOUIS CLIFFORD. (R,C/S—JA-M). District manager, San Francisco office, Joy Mfg. Co.

Long Beach—GORE, DAVID BELL. (M). Sales engineer, Eastman Oil Well Survey Co.

Piedmont—YOPES, PAUL FREDERICK. (C/S—J-M).

San Francisco—REEDER, DAVID BRIERLY. (M). Division manager, Electro Metallurgical Sales Corp. WITT, FRANK. (M). Consulting mining engineer; general manager, Western States Mining Co.

Santa Maria—EVANS, KENNETH RUSSELL. (M). Vice-president, Bell-Casmite Oil Co., and A. E. Bell Corp.

Taft—GRIVETTI, REX MICHAEL. (C/S—J-M). Geologist, The Texas Co.

COLORADO

Climax—COOLEY, CHARLES MILTON. (R,C/S—S-J). Engineer, planning dept., Climax Molybdenum Co.

Denver—HARRIS, JAMES DAWSON, JR. (R,C/S—J-M). District engineer, Rocky Mountain district, Core Laboratories, Inc. STEDMAN, ALAN LEROY. (C/S—S-AM). Construction engineer, Armco Drainage & Metal Products, Inc. WATSON, GEORGE CHARLES. (M). Owner, Domestic Coal Co.

Leadville—GREENLEE, BARNETTE BATES. (R,C/S—J-M). Mine foreman, Resurrection Mining Co.

CONNECTICUT

Ansonia — TOUSSANT, WILLIAM THEOPHILE. (M). Sales metallurgist, Bridgeport Brass Co.

Hartford — DORVEL, ARNOLD ALEXANDER. (J). Metallurgist, Hartford Electric Steel Co.

Riverside—BEAN, JAMES JOSEPH. (M). Mineral dressing engineer, American Cyanamid Co.

Stamford — ANDERSON, ELWOOD ROBERT. (AM). Special assistant to vice-president, manufacturing department, Ethyl Corp.

Torrington — BAKER, ROBERT STUCKEY. (C/S—J-M). Works manager, Torrington branch, American Brass Co.

Westport—WEBER, WILLIAM C. (R,C/S—A-M). Process engineer and director of technical data, The Dorr Co.

FLORIDA

Brewster — CHESSON, MAYWOOD W., JR. (J). Assistant flotation plant superintendent, American Cyanamid Co.

IDAHO

Wallace — RICHARDS, BENJAMIN STEPHENS, JR. (AM). Sales representative, explosives, E. I. du Pont de Nemours & Co.

ILLINOIS

Chicago — DALLMAN, ROBERT ADOLPH. (M). Metallurgist, Robert W. Hunt Co. HANSEN, MAX. (R—M). Associate professor, department of metallurgical engineering, Illinois Institute of Technology. WELLS, RALPH G. (AM). Metallurgist, Carnegie-Illinois Steel Corp.

Hillsboro — RULE, WILLIAM THOMAS. (J). Plant metallurgist, Eagle-Picher Co.

Oak Park — MAXSON, MARSHALL WHITNEY. (M). Chief process metallurgist, Carnegie-Illinois Steel Corp.

KANSAS

Lawrence—HAMBLETON, WILLIAM WELDON. (J). Instructor of petrography, University of Kansas.

Wichita — HADDOX, R. PUTNAM. (J). Junior exploitation engineer, Shell Oil Co. HELLAR, DONALD LOUIS. (M). Geologist, Sohio Petroleum Co. PARRIOTT, ROBERT BENEDUM. (R,C/S—J-M). Geological engineer, Stickle Drilling Co. TATLOCK, THOMAS ALBERT. (M). Production superintendent, J. H. Tatlock. ZOLLER, HENRY E. (M). President, Derby Oil Co.

LOUISIANA

Jennings — BROCK, DONALD MARSH. (M). District manager, Garrett Oil Tools, Inc.

New Orleans—RATLIFF, J. PAUL, JR. (C/S—J-M). Partner and manager, Rey Supply Co.

MASSACHUSETTS

Swampscott — MOORE, JAMES HENRY. (M). Director, metals research department, National Research Corp.

MICHIGAN

Ann Arbor—FREY, DONALD NELSON. (J). Research associate, department of engrg. research, University of Michigan.

Detroit—WIEDMAN, CARL S. (C/S—S-J). Research metallurgical engineer, Carboloy Co.

Ishpeming — ALLEN, ERNEST A. (AM). Geological technician, The Cleveland-Cliffs Iron Co.

MINNESOTA

Calumet—BOLITHO, WAYNE RUSSELL. (C/S—S-J). Assistant chief engineer, Inter-State Iron Co.

Coleraine—VANDELINDER, MARION DELBERT. (C/S—S-J). Mining engineer-trainee, Oliver Iron Mining Co.

Minneapolis — WARREN, ALICE ROCKWELL. (AM). Vice-president and secretary, Langdon-Warren Mines, Inc.

St. Paul—BATHKE, ALFRED SNYDER. (M). Partner, F. H. Bathke.

MISSISSIPPI

Laurel—BAKER, WILLIAM HENRY. (J). Drilling fluid engineer, Magnet Cove Barium Corp. CROWE, JESSE OVEL. (M). Assistant zone superintendent of production, production division, Gulf Refining Co. McGLOTHLIN, JOHN THOMAS. (M). Consulting geologist.

MISSOURI

Bonne Terre—JAMES ALLAN HARRIS. (C/S—J-M). Field geologist, St. Joseph Lead Co.

Columbia — FRAUNFELTER, GEORGE HENRY. (C/S—S-J). Graduate assistant in geology, University of Missouri.

Florissant—DESLODGE, BERNARD FARRAR. (AM). Geologist, Minerva Oil Co. DESLODGE, JOSEPH. (M). President, Minerva Oil Co.

Fredericktown—RIGGS, LAWRASON, III. (R,C/S—S-M). Business representative, Mine La Motte Corp.

Kansas City—NORQUIST, DONALD E. (M). Metallurgical sales, Sheffield Steel Corp.

NEW MEXICO

Carlsbad—JUHOLA, NEIL MATTHEW. (M). Acting mine foreman, Potash Co. of America.

Hobbs—LAMONT, NORMAN. (C/S—S-J). Trainee, Shell Oil Co.

Silver City—GRUNIG, JAMES KITCHELL. (J). Geologist, U. S. Geological Survey.

NEW YORK

Brooklyn—CUTLER, SEYMOUR S. (J). Plant manager, Standard Type Metals Corp.

Jamaica — GOODMAN, HERBERT HAROLD. (C/S—S-J). Metallographer, American Electro Metal Corp.

New York—FRIEDMAN, LOUIS T. (M). Head, department of metallurgical engineering, Sam Tour & Co.

Schenectady — BALDWIN, ELMER EDMUND. (C/S—S-J). Engineer, on rotating assignment, General Electric Co.

White Plains—LORCK, KARL. (M). Head, technical division, U.S.A. branch, Elektrokemisk A. S.

OHIO

Cleveland — KRONBACH, GEORGE EDWIN. (M). Senior metallurgist, Thompson Products, Inc.

Columbus—SMITH, WILLIAM HENKING. (J). Assistant geologist, Geological Survey of Ohio.

Middletown—ELLIS, CEDRIC DOUGLAS. (M). Assistant superintendent, Open Hearth, ISCOR.

Olmsted Falls—IVES, LEE EMMET. (R—M). President, Lee E. Ives, Inc.

Warren—WILLIAMS, JOSEPH OSCAR. (J). Open hearth metallurgist, Republic Steel Corp.

OKLAHOMA

Henryetta — TAYLOR, GENE KINNEY. (M). Vice-president in charge of operation, Ben Hur Coal Co.

Miami — NEAL, CHARLES AIMAN, JR. (AM). Vice-president, Bells Wells Oil Co.

Moore—WILLIAMS, JAMES JUNIOR. (J). Junior engineer, petroleum production, Cities Service Oil Co. (Del.).

Norman—MADDOX, GAISER DAWSON. (R,C/S—J-M). Assistant professor, petroleum engineering, University of Oklahoma.

Oklahoma City — COOKE, JOHN THIEME. (R,C/S—J-M). Petroleum engineer, Sohio Petroleum Co. SCHEIRMAN, GENE LEWIS. (C/S—S-J). Junior exploitation engineer, Shell Oil Co. SVOBODA, FLOYD JOSEPH. (J). Rotary service, The National Supply Co.

Tulsa—AMSTUTZ, RAY W. (C/S—S-J). Junior petroleum engineer, Eariougher Engineering. DERRICK, A. M., JR. (R,C/S—S-J). Junior petroleum engineer, Stanolind Oil & Gas Co. MAUL, ROBERT VINCENT. (M). Chemical engineer, Stanolind Oil & Gas Co.

PENNSYLVANIA

Bethlehem — WAHL, WILLIAM GEORGE. (M). Geologist, Bethlehem Steel Co.

Bristol — SUTER, WILLIAM GUY. (C/S — S-J). College representative, John Wiley & Sons.

Clairton — SMITH, FRED R. (M). Superintendent, open hearth, Carnegie-Illinois Steel Corp.

Groveton — MARSALKA, JOSEPH JEROME. (C/S—J-M). Research laboratory supervisor, Blaw Knox Co.

Hazleton — REESE, ANTHONY GEORGE. (M). Mining engineer, anthracite flood prevention project, Bureau of Mines.

McKeesport — EKHOLM, LAVERNE G. (C/S—J-M). Assistant chief metallurgist, Duquesne works, Carnegie-Illinois Steel Corp.

Philadelphia — DANDO, ELON E. (AM). Divisional sales manager, Aero Service Corp. LANSDALE, PHILIP THOMAS. (M). Metallurgist, Henry Disston & Sons.

Pittsburgh — DRIESSEN, MAXIMILIAAN GUSTAAF. (M). Consulting engineer, Heyl & Patterson, Inc.; Koppers Co. HAMMOND, JOHN A. (AM). Pittsburgh division manager, National Carbon Co. LOUGHREY, DANIEL RIPLEY. (M). Superintendent, open hearth & Bessemer, Jones & Laughlin Steel Corp.

Pottsville — WHAITE, RALPH HAROLD. (M). Mining engineer, Bureau of Mines.

SOUTH CAROLINA

Charleston — KEILEN, JOHN J., Jr. (C/S—S-M). Project leader, West Virginia Pulp and Paper Co.

SOUTH DAKOTA

Lead — RICE, ARTHUR JAMES. (C/S—J-M). Cost engineer, Homestake Mining Co.

TEXAS

Alice—COOK EDGAR LOYD. (J). District engineer, Arkansas Fuel Co.

Ames—WEST, GEORGE WILLIAM. (M). Petroleum engineer, Sinclair Prairie Oil Co.

Austin—BARNES, BYRON ARTHUR. (R,C/S — J-M). Petroleum engineer, Magnolia Petroleum Co.

Corpus Christi — MOORE, ALVAN AUGUSTUS. (M). Partner, Clark & Bus Moore Oil Well Servicing Co.

Dallas — OWENS, DENNIS EMORY. (AM). Superintendent, bottom hole sample laboratory, Core Laboratories, Inc.

Delmita — BIRDWELL, WARRIE RUSSELL, JR. (J). Field engineer, Sun Oil Co.

El Paso — WASHBURN, ALWYN LOUIS. (AM). Co-owner, sales manager, Don A. Carpenter Co.

Ft. Worth—GROGINSKI, PHILIP S. (M). Engineer and geologist.

Hebbronville — McAFEE, ROBERT VANDERVEER. (R,C/S—S-J). Area engineer, Sun Oil Co.

Houston — DODD, JAMES GRADY. (M). Reserve geologist, Tennessee Gas Transmission Co. FORD, ROBERT DAVIS. (M). Public relations manager, Schlumberger Well Surveying Corp. KINLEY, JOHN CARY. (M). Engineer, M. M. Kinley Co. MORIAN, STANLEY COFFIN. (R,C/S — J-M). President and manager, Dixie Chemical Co. PALMER, ARTHUR BOWEN. (M). General manager, Sperry-Sun Well Surveying Co. PLAZA, JOSEPH BREWER. (AM). Reservoir engineer, division office, Stanolind Oil and Gas Co. TENNANT, JOSEPH ALLAN, JR. (M). Economist, Cameron Iron Works.

Lone Star—BOND, WILLIAM ROBERT. (M). Works manager, Lone Star Steel Co.

Midland — BLACKWOOD, JAMES COSBY. (M). Petroleum engineer, Amerada Petroleum Corp. HENDERSON, GEORGE HARVEY. (M). Electric well services supervision, Halliburton Oil Well Cementing Co.

Odem—BRADY, HAROLD JUDSON. (C/S—S-J). Petroleum engineer, Seaboard Oil Co.

Tyler—VOGENTHALER, THOMAS J. (C/S—S-J). Junior engineer, Schlumberger Well Surveying Corp.

UTAH

Salt Lake City—URQUHART, ROBERT DEAN. (M). Mining engineer, Utah Fuel Co.

Tooele — DAWSON, HARMEL ARTHUR. (C/S—S-J). Metallurgist, Combined Metals Reduction Co.

WASHINGTON

Spokane—LINDEMUTH, JACOB H. (M). General superintendent, Mead Works, Permanente Metals Corp.

WISCONSIN

Milwaukee — FOLEY, EDWARD JAMES. (M). Research metallurgist, Ladish Co.

WYOMING

Casper—FANSHAWE, JOHN RICHARDSON, 2nd. (M). Acting district manager, Rocky Mountains, Seaboard Oil Co. of Delaware.

ALASKA

Fairbanks—HELLERICH, GEORGE. (R,C/S — AM-M). Manager, Alaska dredge operations, Brinker-Johnson Co. LOFTUS, THEODORE ALBERT. (M). Superintendent, U. S. Smelting Refining & Mining Co.

BRITISH COLUMBIA

Salmo — STARCK, LOUIS PHILIP. (C/S—S-J). Assistant mill superintendent, Emerald tungsten project, Canadian Exploration, Ltd.

MANITOBA

Bissett—O'HARA, THOMAS ALAN. (C/S—S-J). Surveyor, San Antonio Gold Mines, Ltd.

Winnipeg—ALLAN, JOHN DONALD. (C/S—S-M). Chief geologist, Manitoba mines branch, Department of Mines and Natural Resources.

ONTARIO

Kingston — HONE, ANDRE. (M). Head, physical metallurgy division, Aluminum Laboratories, Ltd.

SONORA

Moreno—SPLANE, JOHN L. (C/S—S-M). General superintendent, Cia. Minera de San Jose.

BOLIVIA

Huanuni — VAN RAADSHOOVEN, WILLEM HENDRIK. (J). Mining engineer, Empresa Minera "San Jose".

BRAZIL

Volta Redonda, Est. do Rio—BASTOS, EURICO ALVES FERREIRA. (J). Assistant engineer, open hearth department, Cia. Siderurgica Nacional.

CHILE

Concepcion—PAIDASSI, JEAN. (M). Professor of metallurgy, University of Chile.

VENEZUELA

Caracas — PIERCE, A. CHARLES. (C/S—S-J). Geologist II, Creole Petroleum Corp.

ENGLAND

London — TYLECOTE, RONALD FRANK. (C/S—JFA-M). Investigator, British Non-Ferrous Metals Research Association.

ICELAND

Reykjavik—TRYGGVASON, TÓMAS. (AM). Consulting geologist, University Research Institute.

SPAIN

Madrid — SOTO, AMADOR GONZALEZ. (C/S—AM-M). Laboratory chief, Iron & Steel Institute of Spain; chief professor of Metallurgy, Escuela Politecnica del Ejército.

SWEDEN

Saxdalen—WALLIN, KARL GUSTAF. (M). Manager, Saxberget mine, Aktiebolaget Zinkgruvor.

SWITZERLAND

Gerlafingen — MAGYAR, STEPHEN. (AM). Research engineer, Von Roll Iron Works, Ltd.

LIBERIA

Monrovia — IMMINK, THEODORE WERNARD. (M). Geologist, Liberia Mining Co.

NORTHERN RHODESIA

Mufulira—NORRIE, JAMES PETERKIN. (R,C/S—A-M). Consulting mining engineer, Roan Antelope and Mufulira Copper Mines, Ltd.

TANGANYIKA

Geita—STANSMORE, NORMAN WILLIAM. (M). Mill superintendent, Geita Gold Mining Co.

QUEENSLAND

Mt. Isa — SPRATT, RICHARD NICHOLAS. (J). Staff geologist, Mt. Isa Mines.

Student Associates

Elected February 15, 1949

John W. Anderson (Rein.)...Univ. Utah
Kenneth L. Davis.....Univ. Utah
Morton J. Disckind.....Univ. Penn
Lloyd S. Elder.....Univ. Utah
Russell G. Goldberg.....Univ. Penn
Grant J. Harvey.....Univ. Utah
Salvatore S. Mele, Jr.....Univ. Utah
Emmett K. Olson, Jr.....Univ. Utah
S. Srinivasan .....Univ. Utah

Elected March 16, 1949

John D. Abbott.....Mich. Min. & Tech.
Eugene M. Adrian, Jr.....Univ. Alaska
Paul J. Ahearn.....MIT
Clarence W. Ahlstrom
Mich. Min. & Tech.
George E. Aiken.....Univ. Alaska
Kenneth E. Anderson
Mich. Min. & Tech.
Stewart J. Andrews.....Univ. B. C.
Walter K. Arbuckle.....Texas A&M
Charles J. Awe, Jr.....Univ. Alaska
Andrew V. Bailey.....Univ. Ala.
Allen F. Baker.....Texas Tech. Coll.
James R. Barkley.....Univ. Nev.
Alfred E. Barröll.....Univ. Okla.
Roy M. Bauer, Jr.....Stanford Univ.
William S. Bauman.....Univ. Wisc.
Billy D. Biggs.....Texas Tech. Coll.
Donald D. Bilis.....Texas Tech. Coll.
John W. Bisbing, Jr.....Penn. State
J. A. Blackwell, Jr.....Texas Tech. Coll.
Tarlton J. Blair.....Univ. Utah
Martin L. Bond.....Univ. Wichita
Oliver W. Borgeson..Mich. Min. & Tech.
Waylon H. Bostick....Texas Tech. Coll.
Dewey D. Bowling.....Colo. Sch. Mines
Donald L. Brehm.....Univ. Wichita
Robert G. Brooks.....Univ. Wichita
Dean D. Burgan.....Ohio State
Jack Bysterbosch.....Univ. B. C.
N. Bruce Calder.....Univ. Texas
Edward J. K. Callaghan
Melbourne Univ.
Riley V. Carlton.....Texas Tech. Coll.
Plinio M. Carvalho...Mich. Min. & Tech.
Carlos F. Castro.....Univ. B. C.
Angelos T. Chatas.....Univ. Texas
Pete M. Christy, Jr.....Univ. Wichita
Daniel J. Chupinsky.....Penn. State
Charles R. Clark.....Colo. Sch. Mines
Edward C. Clark.....MIT
Donald C. Codville.....Univ. B. C.
Percy R. Coffin.....Univ. Alaska
Dellum C. Collins, Jr.....Texas A&M
Wilson H. Collins.....Univ. Ala.
Donald G. Comeaux.....Univ. Wichita
Lory S. Conder.....Colo. Sch. Mines
Charles H. Conn.....Ohio State
William C. Cook.....Univ. B. C.
Jack P. Covey.....Univ. Wichita
Arthur E. Creamer.....Univ. Okla.
John D. Cruse.....Univ. Wichita
Luiz Coelho Correa da Silva
Carnegie Inst. Tech.
Robert N. Davidson....Colo. Sch. Mines
J. Lee Davis.....Texas Tech. Coll.
Patrick E. Dempsey.....Queens Univ.
Charles W. Denney.....Univ. Wichita
Pete A. De Santis.....Colo. Sch. Mines
James W. Dougherty, Jr.
Carnegie Inst. Tech.
Robert L. Draper.....Univ. Ala.
Harley F. Drury, Jr.....Univ. Texas
Eugene A. Eastman..Mich. Min. & Tech.
Charles L. Earl.....Texas Tech. Coll.
James H. Eastman.....Univ. B. C.
Lyle D. Eberly.....Univ. Wichita
Wendell R. Edgell.....Univ. Wichita
Thomas M. Esmond...Texas Tech. Coll.
Edward M. Feely.....Colo. Sch. Mines
Billie K. Freeman.....Texas Tech. Coll.
Victor S. Frigon.....Univ. Wichita
Lester K. Funderburk..Texas Tech. Coll.
Claude D. Gaines, Jr...Texas Tech. Coll.
Peter E. Galli.....Univ. Alaska
Richard D. Gardner.....Stanford Univ.
Howard L. Garrett.....Colo. Sch. Mines
John H. Geyer.....Lehigh Univ.
William H. R. Gibney.....Univ. B. C.
Charles M. Goin.....Univ. Wichita
Donald J. Gorges.....Univ. Wichita
Walter C. Granger.....Univ. Ala.
Lawrence F. Gray.....Univ. Wichita
Howard R. Green.....Univ. Wichita
Joseph R Green.....Univ. Wichita
Daniel R. Grubb.....Univ. Wichita
Joseph Guriand .....MIT
John H. Hager.....Mich. Min. & Tech.
Phipps A. Hager.....N. C. State
George L. Hainkel.....Univ. Wichita
Donald D. Hall.....Wash. State
John A. Halpin.....Mich. Min. & Tech.
Joseph L. Hammer.....Texas A&M
Edward J. Hannahan, Jr.
La. State Univ.
Milfred H. Hanson.....Univ. Wichita
Garth B. Harlan.....Colo. Sch. Mines
Milton B. Harper.....Va. Poly. Inst.
John R. Harris.....Texas A&M
Ellis C. Helge.....Mich. Min. & Tech.
James R. Herrington, Jr.....Univ. Okla.
Harold D. Hess.....Oreg. State Coll.
Stanley Hodgson.....Univ. B. C.
Stanley C. Holmes.....Univ. Ala.
Robert N. Honeyman.....Lehigh Univ.
James G. Hood, Jr.....Va. Poly. Inst.
Frank D. Hoyt.....Penn. State
Toivo A. Johnson....Mich. Min. & Tech.
Stephen G. Johnston..Texas Tech. Coll.
George L. Jones.....Texas Tech. Coll.
Stan A. Kanik.....Univ. B. C.
Edward L. Karr, Jr.....Colo. Sch. Mines
Jerome W. Kaufman.....Lehigh Univ.
Lewis B. Kelly.....Univ. Wichita
Alton R. Kendrick.....Texas Tech. Coll.
Joe D. Kenworthy.....Texas Tech. Coll.
Jack Keverian .....MIT
Paul T. Kinney, Jr.....Penn. State
Andrew C. Kitzman, Jr.
Texas Tech. Coll.
Thomas Kneen.....Univ. B. C.
George A. Koehl, Jr.....Univ. Texas
Frederick F. Kohls.....Univ. Alaska
Eino A. Koski.....Mich. Min. & Tech.
Edward M. Laczynski
Mich. Min. & Tech.
William C. Lake.....Univ. Wichita
John W. Lampert.....Colo. Sch. Mines
Lionel N. Larson.....Mich. Min. & Tech.
Albert G. Leach.....Texas Tech. Coll.
William H. Leach.....Ohio State
Russell Lee.....Texas Tech. Coll.
Earl F. Lewis.....Texas A&M
Sing-Bay Li .....MIT
Avis A. Lieb.....Texas Tech. Coll.
Richard M. Linehan.....Univ. Wichita
Thomas P. Liss.....Mont. Sch. Mines
James D. Little.....Univ. B. C.
Ernest T. Loveless, Jr.....Univ. Wichita
Frank W. Lutter.....Univ. Calif.
Willis J. Magathan.....Univ. Wichita
Charles M. Mallette....Colo. Sch. Mines
Derek Manderson.....Melbourne Univ.
Clyde D. Martin.....Texas Tech. Coll.
Hugh J. Matheson.....Colo. Sch. Mines
Ronald Mathews.....Univ. Alaska
Wilfred J. Matthews.Mich. Min. & Tech.
Charles R. Mayfield.....Univ. Wichita
Robert J. McArdle...Mich. Min. & Tech.
Charles K. McArthur, Jr.
Mich. Min. & Tech.
Frederick M. McCoy.....Univ. Okla.
Dorrell D. McCurry....Texas Tech. Coll.
Douglas H. McGinness....Univ. Wichita
William P. McKee, Jr...Texas Tech. Coll.
Elbie G. McNeil.....Univ. Wichita
Chester F. Millar.....Univ. B. C.
Loyle P. Miller.....Univ. Okla.
John E. Moon, Jr.....Univ. Alaska
John O. Moore.....Texas Tech. Coll.
James A. Morris.....Univ. Wichita
John D. Morris.....Univ. Okla.
Hugh W. Naismith.....Univ. B. C.
David H. Neiman.....Univ. Wichita
Donald E. Nulk (C/S J-S)
Carnegie Inst. Tech.
Ossi E. Palasvirta...Mich. Min. & Tech.
Everett M. Patterson...Colo. Sch. Mines
O. Anthony Payne.....Univ. Utah
Philip K. Pearson, Jr.....MIT
Ernest Peters.....Univ. B. C.
George Pinsky, Jr.....Univ. B. C.
Lewis R. Pomeroy, III.....Texas A&M
Gordon W. Powell.....MIT
Ralph W. Preston, Jr. (Rein.)..Univ. Ky.
Leslie E. Price.....Mich. Min. & Tech.
Ronald B. Pruet.....Texas Tech. Coll.
William B. Quesenbury, Jr...Texas A&M
Melford F. Rabalais.....La. State Univ.
Gerald V. Ramsey.....Univ. Wichita
Edward G. Reigle.....Texas Tech. Coll.
Herschel L. Riddle....Texas Tech. Coll.
Mark B. Ringstad (Rein.)..Univ. Alaska
John Robertson, Jr.....Colo. Sch. Mines
Robert W. Robertson.....Univ. B. C.
Ivan B. Robinson.....Colo. Sch. Mines
Murray Sales .....CCNY
E. Richard Schneider.....Univ. Alaska
Edfred L. Shannon, Jr.....Univ. Calif.
Claud L. Sheats, Jr.....Univ. Wichita
Nicholas Sheptak .....Cornell Univ.
William Shindle.....Univ. B. C.
Cleo C. Smith.....Univ. Wichita
David M. Smith.....Univ. Alaska
Robert Smith.....Melbourne Univ.
Wilbert M. Smith...Mich. Min. & Tech.
James B. Spaulding...Texas Tech. Coll.
Joseph N. Syeingasser....Va. Poly. Inst.
John K. Stewart.....McGill Univ.
Joseph A. Stickney.....Univ. B. C.
Joseph M. Stitt.....Univ. B. C.
Doyle L. Stone.....Texas Tech. Coll.
Stephen W. Stookey.....Univ. Alaska
Harry A. Stormer.....MIT
Roy A. Stuart.....Univ. B. C.
Judson D. Sweet.....Penn. State
Martin E. Tarline.....Univ. Wichita
John W. Taylor.....Univ. Calif.
Spencer L. Taylor.....Univ. Okla.
Jim B. Thomas.....Texas Tech. Coll.
Nelson R. Thomas.....Univ. Wichita
Raymond J. Thomson.....Ohio State
George Trowsdale.....Univ. B. C.
Chester N. Truax.....Univ. Pittsburgh
Ali Ulubay .....Lehigh Univ.
Verle B. Utzinger.....Univ. Ill.
William D. Walther.....MIT
H. V. Ward.....Univ. Okla.
Edward B. Wardell....Texas Tech. Coll.
Wyman M. Warren.....Univ. Wichita
Robert W. Watchous.....Univ. Wichita
Robert M. Weaver.....Va. Poly. Inst.
Richard H. Widmyer.....Ohio State
S. A. Womack, Jr.....La. State Univ.
Jack L. Yinger.....Univ. Wichita
Wilfred R. Young.....Texas Tech. Coll.
Stephen Zenczak .....Ohio State

Aerial Photographic Contour Maps for Strip Mines

By GEORGE HESS* and R. H. SWALLOW,† Member AIME

The purpose of presenting this paper is to show:

1. The applications of aerial photography to the map requirements of strip mining.
2. The methods and procedures for producing accurate aerial contour maps.
3. The advantages of aerial contour mapping over stadia or plane table methods.

Introduction

Aerial photography was once a crude, uncertain tool. Today it is a precision mapping instrument which saves important time and money for strip mining and other industry.

Aerial photography began in the boxkite days of aviation. The Army first used it for rough reconnaissance photographs. Then, in the early Twenties, industry began to use aerial photographs of their plants and facilities for advertising or annual reports. The quality of these pictures was not very good by today's standards, but this work began the development of better cameras, better lenses, better photographic techniques.

Then, some farsighted engineers and aerial photographers found that if the camera's axis were vertical to the earth's surface, these pictures could be the source of valuable mapping information. By viewing these pictures in stereoscopic pairs, accurate measurements could be made and contour maps produced from this aerial photographic base. So the aerial mapping business developed, using the plane and aerial camera to collect the data, working with skilled ground parties who established a network of ground control for this map information photographed from the air.

Over the following years, a whole new science developed, known as photogrammetry. Precision cameras and lenses were perfected, and the narrow view of the surveyor's transit was broadened to the vast perspective of the mapping plane.

Stereoscopic Coverage Obtained

Today in making aerial topographic maps, aerial photographs are exposed so that full stereoscopic coverage for the survey area is secured. To obtain true elevations these photographs are processed through a series of precision measuring and contouring instruments which employ a principle similar to the military range finder.

Here is how aerial mapping is being used by your industry. Topographic maps are but one of three products from aerial photographic surveys. *First*, there are the individual photographs. These are taken in flight strips, exposed with an overlap, just as shingles on a roof overlap. Exposures are overlapped from 55 to 60 pct along the line of flight so that a large part of the area in one picture also appears on the adjacent photograph. Successive stripe are flown with a side-lap of between 20 and 25 pct. Each point on the ground thus will be somewhere near the center of at least one photograph in the series. They may be studied under a stereoscope and relief seen in a third dimensional effect. Geologic features that may go unobserved in ground exploration are often detected under stereoscopic inspection. Moreover, though field checking is not obviated with these aerial photographs, it is directed toward critical areas and toward worthwhile anomalies.

Aerial Photographic Mosaics

The *second* product of an aerial survey is the photographic mosaic. This is an assembly of carefully matched aerial photographs in mosaic form. Although not as accurate as the topographic map, it does reveal a wealth of cultural detail in true relative scale. Since the mapping plane is flown over the area at a fixed altitude, the peaks and valleys are pictured at different scales. During compilation these scale differences are compensated by adjusting one vertical picture to another according to plotted ground control positions. Only extreme variations in ground elevation cannot be

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FIG 1—Pilot and photographer mapping team.

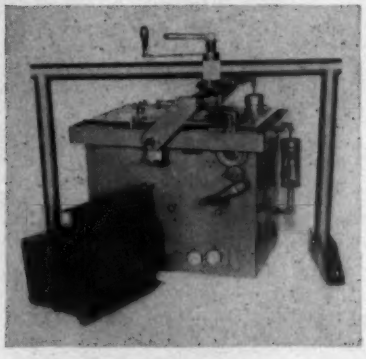

FIG 2—The Brock camera, which employs selected flat glass plates for precision mapping.

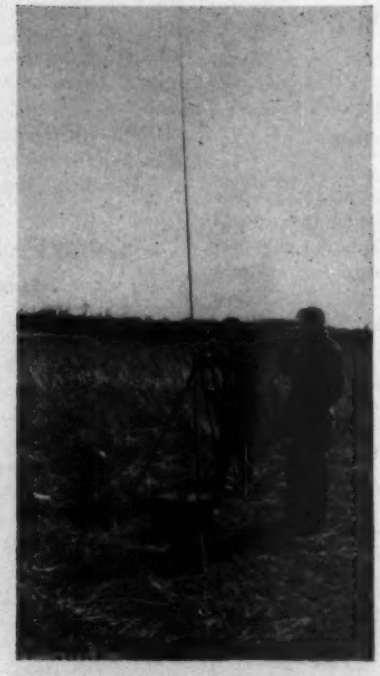

FIG 3—Field survey crews establish minimum ground control.

reconciled accurately. In reasonably flat country, the mosaic is a good map for any use except where contours are required.

Finally, the most refined product of the aerial survey is the topographic map. These conform to any specifications set up for mapping performed by ground methods. It is far faster than ground methods—its cost compares favorably—and it is more accurate.

Aerial Method Appraised

You are familiar with plane table and stadia methods. The illustrations and following explanation may help you to appraise the aerial method: first, the mapping team—pilot and photographer (Fig 1). They must work as a highly coordinated team because the mapping plane moves along at about 120 miles an hour, and pictures are made at intervals of 10 to 20 sec. There is no time for discussion or argument. The pilot must develop a high degree of skill in keeping the plane exactly on course and parallel to the earth's surface; the photographer must operate his precise mapping camera rapidly, checking the flight course for full coverage.

Mapping flights are made in late fall, winter, or early spring because then foliage does not obscure the ground. Most mapping photographs are taken between 10 a.m. and 2 p.m. for best lighting conditions. The plane used is often a single-engine craft—a light, stable, workhorse plane.

The Brock camera used for topographic mapping is an important refinement over the film type cameras. In the past, aerial pictures usually have been taken on film which is subject to expansion and contraction in developing and processing. This leads to significant distortions which no process can fully correct. The Brock camera, however, uses selected flat glass plates because of their dimensional stability (Fig 2).

Minimum Ground Control

In constructing the topographic map from these aerial photographs, a minimum amount of ground control is needed. Base control is run with theodolites, carrying horizontal and vertical measurements simultaneously. Horizontal closures average better than 1 in 20,000 and vertical control must close 0.05 ft per mile run.

Radio transceivers are used for communication between instrument men and rodmen. Since most shots exceed 3000 ft, visual signals are not practical (Fig 3).

Tilt Correction and Contouring Accomplished

Truly vertical photographs with the plane of the picture absolutely horizontal are exceptional, for rarely can an airplane be kept in alignment for a series of exposures. Thus minor tilts occur when the pictures are taken. Correcting projectors eliminate the tilt that occurs in the original photography; they are calibrated to correct for as little as 30-sec tilt (Fig 4). Even this, if left uncorrected, would affect the accuracy of the finished map.

After such correction, the plates are placed in a measuring stereometer, which operates on the same principle as the old parlor stereopticon (Fig 5). However, this has been refined and perfected so that the operator sees a brilliant third-dimensional model. Within the optics of the stereometer are cross-hairs acting as a floating mark, which the operator easily and accurately brings to co-incidence with the ground. A setting is made for each contour, and the operator traces all points at this elevation onto the transparent overlay which covers the stereoscopic image. He works through the successive elevations, until the entire area has been contoured according to the predetermined scale. On work of special urgency, this and the other steps of map compilation can proceed in laboratory and drafting rooms on a double shift basis.

Finally, the individual contoured templates or overlays are assembled and the finished map tracing made (Fig 6).

Scales of maps made by the aerial method may range from 1 in. equals 100 ft to 1 in. equals 1000 ft, and the contour interval may vary from 2 to 5 to 25 ft or greater, as required. Standard specifications provide that 90 pct of the map be accurate within one-half contour interval, and that no part shall be in error by more than one contour interval. The completed maps can be made on any type or size of tracing cloth or hard copy paper.

The topographic map affords an excellent base for the plotting of such details as property owners' names, drill holes, legends, outcrop, and so on.

FIG 4—Massive correction projectors eliminate any tilt in the original photography.

FIG 5—Operator contouring on transparent overlay on stereometer.

Advantages of Aerial Contour Maps

It is not the purport of this paper to explore the uses and advantages of contour maps, for these are well known to open pit mining engineers. However, it is important to consider these advantages of aerial contour maps:

COSTS

Aerial contour maps range in cost from $1.50 to $2.00 per acre. Here is a comparison of costs with maps made by ground methods. Recently one large strip mining company surveyed, traced, and completed maps by the older methods, for an area of 2045 acres. Scale was 1 in. equals 100 ft; the contour interval was 5 ft. Total cost for engineers, draftsmen, helpers, and so on was $5994—or a cost of $2.92 per acre.

At about the same time, a tract with comparable topography was contoured, traced, and completed by aerial methods, at the same scale and contour interval. This area comprised 7210 acres. Total costs for flying, photographing, ground control, and tracing were $13,289—or $1.84 per acre.

While cost will vary according to size of area, topography, and delivery schedule, the aerial method brings a material saving over ground costs on areas of 1000 acres or more. However, on any survey that can be accomplished in less than two months time by one plane table party the advantages of the aerial method are considerably less.

TIME

Important savings in time are

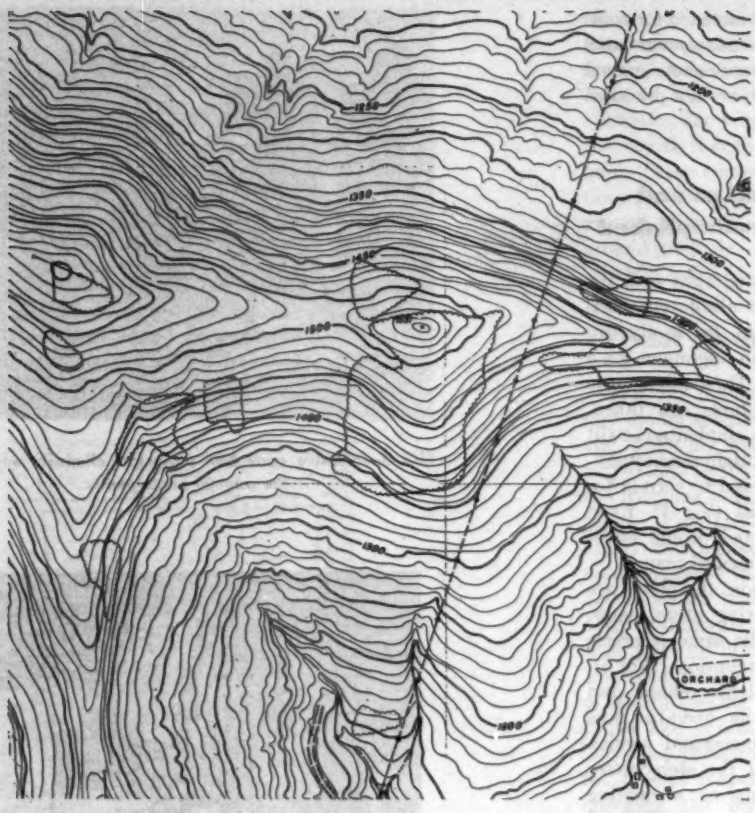

FIG 6—Typical section of typographic map prepared from an aerial photographic base.

possible through the aerial method. The aerial photography requires days; ground methods need weeks and months. Since the aerial method needs only a minimum of ground control it is not necessary to cut through brush or rough terrain. The line of least resistance can be followed because points are not required as frequently as in stadia or plane table methods. Moreover, the drawing of contours is considerably more rapid with the use of stereometers than plane tabling or interpolating stadia field notes. Consequently, the time schedule for production of the finished map is cut at least in half in comparison with the time for the older methods.

GREATER DETAIL

The aerial topographic map is a more refined product; all details, such as ponds, buildings, power lines, fence lines are secured. In ordinary ground methods many of these are missed as a result of human error. Better expression in the actual contour lines is obtained through the aerial method, and no minor terrain change is overlooked.

INDEPENDENT OF TERRAIN

In the mapping of irregular, difficult or inaccessible terrain, the advantages of the aerial method are obvious. The mapping plane soars swiftly over rugged country, independent of the terrain problems facing the ground surveyor.

SUPPLEMENTARY INFORMATION

From the basic aerial photographs made for the contour maps, individual prints and mosaics may be made at a cost of about 4¢ to 6¢ per acre. In prospecting an area where local or government quadrangle maps are not available, these prints or mosaics facilitate reconnaissance.

In flying for contour maps, it is advantageous to overfly the area to be contoured in order to get the boundary features. The contact prints and mosaics, therefore, will cover a larger area than the contour maps. After prospecting and drilling it is then only necessary to have that part of the area contoured which is essential to the future mining operation.

It is only in the last few years that the advantages of aerial contour mapping have been realized. But the aerial method has now proved itself as to accuracy, and as to savings in time and costs. Aerial photography works for your industry today in many areas in West Virginia, Kentucky and Indiana—as well as in the iron ore areas: the Marquette Range in Michigan, and the Mesabi and Cayuna Ranges in Minnesota. It is one of the important new tools which reduces costs and speeds development schedules for the open pit mining industry.

Drying Low-rank Coals in the Entrained and Fluidized State

By V. F. PARRY,* J. B. GOODMAN,† and E. O. WAGNER†

Summary

The low-rank coals containing 10 to 50 pct natural bed moisture represent over half of the tonnage reserve of the available solid fuels of the United States, but only about 2 pct of United States coal production is derived from these fuels. Increased utilization of these large reserves will result if the bed moisture can be removed at the mine in high-speed low-cost processes. This paper presents a theoretical and experimental study of the factors affecting high-speed drying of coal dusts.

The time required to heat particles of coal is proportional to the square of their diameter, and it is calculated that the probable time in minutes is equal to $6D^2$. In other words, a $\frac{1}{16}$ in. coal particle should be heated to drying temperature in 1.5 to 2.0 sec. Likewise, $\frac{1}{4}$ in. particles should be heated in about 6 sec. The net heat required to dry subbituminous coal and lignite varies from 240 to 375 Btu per pound, depending upon the moisture removed, and this heat can be obtained from 42 to 61 cu ft of hot gases at 600°F. The necessary heat also can be obtained from 7.5 to 11 cu ft of gas at 2000°F.

A description of the design and operation of a pilot plant for flash drying coal dusts is presented. This plant dries $\frac{1}{16}$ in. by 0 coal dust in suspension in 1.5 to 2 sec with 600°F gas at a rate of 1300 lb per hour per square foot of column area and operates continuously at an efficiency of about 85 pct. The design and operation of another pilot plant for drying $\frac{1}{4}$ in. by 0 coal dusts is also described. This unit dries coal in the fluidized state using the sensible heat of gases introduced at 2000°F and processes coal at a rate of about 1500 lb per hour per square foot of grate area at 85 to 90 pct efficiency.

Over 90 pct of the bed moisture of low-rank coal dusts can be removed by the methods described. The heating value of lignite can be increased 45 pct and that of subbituminous coal 25 pct in a few seconds. The physical and chemical properties of coal dusts before and after drying are presented in the report, and it is shown that the bulk density of the dried coal is equal to that of the raw coal. This phenomenon makes it possible to ship 25 to 45 pct more heat in a railroad car with consequent savings in freight costs.

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Introduction

For several years the Subbituminous Coal and Lignite Section of the Coal Branch of the Bureau of Mines at Golden, Colo., has been concerned with upgrading low-rank coals by removal of natural bed moisture. These fuels contain 10 to 50 pct total moisture, which reduces their industrial value considerably. In 1938, investigations were initiated in cooperation with the University of North Dakota to study drying of lignite by the Fleissner process with heat derived from high-pressure saturated steam. Two pilot plants were built, and two reports were published giving the results of this work.[1,2] It was demonstrated that lump lignite and subbituminous coal

could be dried readily by the Fleissner process, but it was not feasible to treat slack sizes. From pilot-plant tests it was proved that the capacity of steam-drying plants treating 1 by 2 in. lump should be in the range of 100 lb per hour per cubic foot of autoclave volume; and it was indicated from studies of costs of large plants that the cost of drying lignite lump should be 35 to 50 cents per ton based on 1940 price levels. Experimental work was carried on intermittently for several years, but no commercial plants were built because coal producers and industrial users desired to dry slack coal in most instances, and the upgrading of lump lignite was not particularly attractive to them.

The removal of bed moisture from the slack sizes of lignite and subbituminous coal is somewhat more difficult than the removal of surface moisture from ordinary bituminous slack coal, and the methods used for the latter have not been very successful with the low-rank coals because of the additional time required to remove moisture from the interior of the coal lumps. The rotary drier does not perform efficiently on subbituminous coal or lignite, and considerable dust is lost in the processing. For example, one plant treating ¾ in. slack coal at a rate of 10 tons per hour reduces the total moisture content from 31 pct to only 20 pct in 30 to 50 min through a 50 ft kiln. Another plant treating ¾ in. slack at a rate of 12 tons per hour in tandem kilns totaling 90 ft in length reduced the total moisture from 12 to only 6 pct in about 90 min. The efficiency of these kilns, operating on subbituminous coals, is only about 43 pct, and the loss of dust is considerable. The foregoing plants are the only commercial units now operating on low-rank coals in the United States, but much interest has been expressed by operators in the possibilities of upgrading these fuels by drying, particularly for preparation preliminary to briquetting.

The growing interest in utilizing the low-rank fuels as raw material for synthetic fuels and for other industrial purposes has focused attention on cheap, high-speed methods for removing bed moisture. If these fuels can be dried cheaply at the mines and transported and stored at industrial plants, the present barriers to utilization would be largely removed because the heating value of dry lignite is only 15 to 20 pct less than the heating value of the best dry bituminous coals, whereas, in its natural state, lignite contains only half the heat of good bituminous coal.

Since the natural moisture in low-rank coals is distributed more or less uniformly within the coal substance, the center of each lump must be heated to at least 212°F to remove a substantial portion of the moisture. The report discusses the time required to heat particles of coal, and it is shown that the time is proportional to the square of the diameter. Particles of coal of 14-mesh size (0.046 in.) can be heated in about 1 sec, but a 1.0 in. lump of coal will require about 360 sec. This great difference in time explains why it is inefficient to dry slack coal that varies considerably in size and contains a substantial portion of lump pieces. In other words, slack coal must be subjected to heat for the time necessary to treat the large lumps in order to attain drying. This results in overdrying of the fines, which could be processed in a much shorter time. In a rotary kiln the fine material covers the coarse particles and prevents heat from reaching the lumps. This results in a much longer drying time. As previously mentioned, 1 to 2 hr may be required to process the low-rank slack coals in rotary kilns, while it is theoretically possible to dry 1 in. slack in 6 min if heat can be transferred to the coal.

When bed moisture is removed from the low-rank coals, considerable shrinkage occurs, which makes the dried coal friable and causes degradation during handling. Since the natural tendency of low-rank fuels is to degrade to small sizes, it is believed that they should be processed in the dust form for the large-scale industrial uses.

SUMMARY OF RESULTS

This report presents results of experiments on the flash drying of $\frac{1}{16}$ in. by 0 dusts using waste heat and experiments on drying ⅛ in. by 0 dusts in the fluidized state using high-temperature inert gases. The object of the investigation was to develop engineering data that could be used for designing low-cost, high-speed processes for treating these fuels. The experimental work was done in continuous pilot plants of 100 to 300 lb per hour capacity. The study has been under way for about one year, and this is the first report of progress.

The investigation thus far indicates that waste heat at 600°F can be used efficiently to dry $\frac{1}{16}$ in. by 0 coals in suspension in 1.5 sec, and enough engineering data are available for design of larger plants. If high-temperature gases using primary heat are employed, low-rank coals of ⅛ in. by 0 size can be dried in fluidized beds at very high efficiency and at rates of ¾ to 1.0 ton per hour per square foot of column area. At this capacity, a drying unit for a 2000 ton per day unit would be only 12 ft in diameter and about 15 ft high, and the cost of drying would be in the range of 25 to 35 cents per ton.

The experimental results on fluidized drying indicate efficiencies of 86.5 pct, excluding radiation, and overall efficiencies of 76.4 pct. When operating a large plant, it is calculated that overall efficiencies of 85 to 90 pct can be attained. The space velocity of hot gases in the fluidized column is about 9 fps, somewhat higher than the space velocity of a stable fluid bed, and the density of the fluid bed is 10 to 12 lb per cubic foot.

TIME REQUIRED TO HEAT PARTICLES OF COAL

From theoretical considerations of the time required to heat different sizes of coal to a given temperature distribution, it is evident that the size of coal determines the time required to heat.

The theory of conduction of heat through homogeneous solids, developed mathematically by Fourier and his followers, is not directly applicable to conduction of heat through subbituminous coal and lignite, as these fuels are not homogeneous in structure. In addition, they constantly undergo both physical and possibly some chemical changes during the process of heating to temperatures required to remove all the moisture. Nevertheless, Fourier's mathematical procedure, with suitable limitations and modifications, can be used to calculate the temperature history of particles of coal that are heated in a fluid medium. Burke, Schumann, and Parry[3] have suggested a solution to this problem and have proved that the law of squares can be applied to this case, even though the thermal constants may vary with temperature and the temperature may vary with time. This law states that the time required to heat a body to a definite condition or temperature distribution is proportional to the square of some linear dimension of the body. In the case of spheres, the time required is proportional to the square of the diameter.

When the source of heat is relatively unlimited, such as with condensing

steam or the condition in a fluidized bed, and the properties of the material being heated govern the rate of acceptance of heat, the time required to heat spheres to bring the center temperature to about 95 pct of the surface temperature is:

Time of heating, in minutes

$$= 0.37R^2/K$$

(where K = thermal diffusivity*)[4]

(Refer to Fig 5 of the solution previously discussed[3].)

Consider a solid sphere of subbituminous coal or lignite immersed in an envelope of steam or in a heated fluidized bed. Assume that the outer surface of the lump is heated instantaneously to the temperature of the heating medium and maintained at this temperature. Now if it is assumed that the coal particles have an average specific heat of 0.50, a density of 78 lb per cubic foot and a thermal conductivity of 0.25 Btu per hour per square foot per degree F per foot, the time required to heat the particle to any average temperature distribution can be calculated from the laws of conduction referred to above. Using these constants, the thermal diffusivity of average low-rank coals can be calculated. This term is the ratio of conductivity to the product of density times specific heat, or $K = k/\rho c_p$. It is obtained from the expression giving the general differential equation for unsteady heat conduction derived from the basic Fourier equation for conduction of heat by assuming that conductivity is constant. Although this simplifying assumption is made, it has been proved that the law of squares still applies when lumps of coal are heated.

$$K = \frac{0.25}{78 \times 0.50} = 0.00641 \text{ sq ft per hr.}$$

$$= 0.0154 \text{ sq in. per min.}$$

Heating time, in minutes =

$$\frac{0.37R^2}{0.0154} = 24R^2$$

Heating time, in minutes =

$6D^2$ (D = diameter of particle, inches)

Fig 1 shows a plot of the foregoing equation and expresses the theoretical time required to heat particles of coal in an atmosphere of saturated steam or in a fluidized bed. In simple language it tells us that particles of 0.05 in. diam (14 mesh) should be heated in 1.0 sec, while particles 1.0 in. in diameter should require about 360 sec. The points on this figure are experimental data which will be discussed later. Point A represents the time of contact of 1/16 in. by 0 particles in the flash drier; point B the time of contact of 1/4 in. by 0 particles in the fluidized drier; point C the time required to heat 1 1/4 in. lumps with saturated steam; and point D the time for heating 1.75 in. lumps in saturated steam.

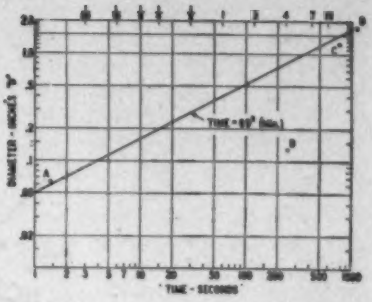

FIG 1—Time required to heat particles of coal.

NOMENCLATURE AND DEFINITIONS RELATED TO DRYING LOW-RANK COALS

Because of the considerable change in weight when low-rank coals are dried, ordinary methods of expressing the moisture removed may be confusing. For example, if a lignite containing 35 pct moisture is dried to a product containing 5 pct moisture, it is commonly considered, by making a simple subtraction, that the coal has lost 30 pct in weight. This is not true, and the estimation is in error by 5 pct. The true weight loss is 31.6 pct. These differences become significant when drying the low-rank coals, therefore it is necessary to adopt a precise nomenclature for expressing results of drying.

The "improvement ratio" = R is the ratio of the weight of coal before drying to the weight after drying. If no dust or fixed gas is lost, this also expresses the ratio of heating value, volatile matter, fixed carbon, and ash after and before drying. The improvement ratio obtained by weight (R_w) is related also to the moisture content before and after drying, and, if no dust or volatile matter is lost, the moisture contents before and after drying must be compatible with the moistures estimated from the weight ratio. It follows also that, if moisture determinations are correct, the dust lost in the system can be calculated by comparing with the weight ratio. Because of the confusion that can arise from inaccurate expressions of results of drying, the authors have adopted the following nomenclature to express results.

Nomenclature

M_1 = percentage moisture in coal before drying.
M_2 = percentage moisture in coal after drying.
W_1 = weight of coal before drying.
W_2 = weight of coal after drying.

R_w = improvement ratio = W_1/W_2 [1]

R_m = improvement ratio = $(100 - M_2)/(100 - M_1)$ [2]

$$R_v = \text{improvement ratio} = \frac{\text{volatile content after drying}}{\text{volatile content before drying}} \quad [3]$$

$$R_c = \text{improvement ratio} = \frac{\text{fixed carbon after drying}}{\text{fixed carbon before drying}} \quad [4]$$

$$R_a = \text{improvement ratio} = \frac{\text{ash content after drying}}{\text{ash content before drying}} \quad [5]$$

$$R_h = \text{improvement ratio} = \frac{\text{heating value after drying}}{\text{heating value before drying}} \quad [6]$$

$R = R_w = R_m = R_v = R_c = R_a = R_h$ when no dust or fixed gas is lost. [7]

U = "ultimate improvement ratio" = $100/(100 - M_1)$ [8]
This represents the maximum improvement by extracting all moisture without liberation of fixed gases.

$$D = \text{per cent of drying} = \frac{U(R-1)100}{R(U-1)} = \left(1 - \frac{M_2}{R_m M_1}\right) 100 \quad [9]$$

This represents the percentage of total water in the raw coal removed during the drying process.

$M_2 = 100 - R(100 - M_1)$ [10]

$W_2 = W_1/R$ [11]

$$L = \text{dust loss, percentage of dried coal} = \left(1 - \frac{R_m}{R_w}\right) 100 \quad [12]$$

X = pounds of moisture removed per pound of original coal = $1 - (1/R)$ [13]

---

* Thermal diffusivity = k/cs = the rise in temperature produced in 1 cc of the substance by 1 cal flowing in 1 sec through 1 sq cm of a layer 1 cm thick having a difference of 1°C between the faces.
c = Specific heat of material.
s = Specific gravity of material.
k = Thermal conductivity.

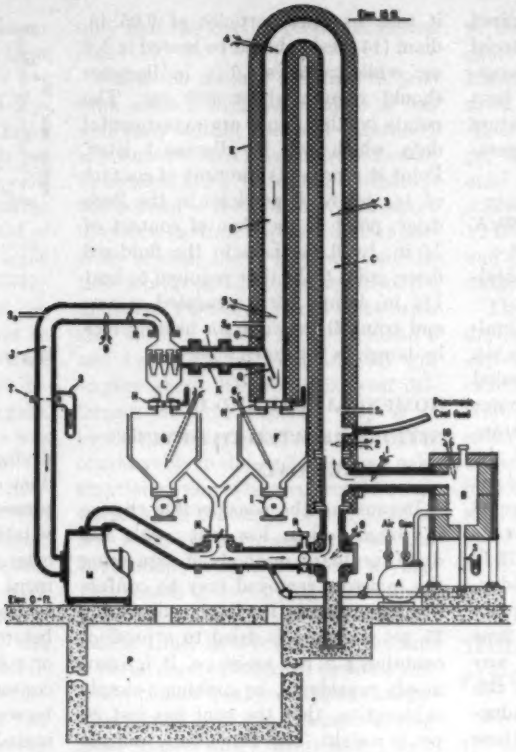

FIG 2—Flash dryer for fine coal.

A "Maxon" air-gas premixer
B Hot gas generator
C Flash drying column—"up section"
D Flash drying column—"down section"
E Mineral wool pipe insulation—3½ in. thick
F Coarse dust receiver—3.45 cu ft capacity
G Fine dust receiver—3.45 cu ft capacity
H Wafer valves—4 and 6 in. and adapters
I Discharge valves—Plug—R.P.—3 in.
J Thin wall ducting—4 in.
K 85 pct magnesia insulation—1¼ in. thick
L "Aerotec" dust collector
M "Spencer" turbo-compressor
N Waste-gas butterfly valve—4 in.
O Packed slip expansion joint—6 in.
P Dry coal storage pit—5 by 5 by 5 ft.
Q Coarse dust separator
R Regulating valves for recirculation
S Differential and static pressures (S_{1-1-2})
T Recirculating gas orifice meter
U P.O.C. regulating valve

HOT GAS REQUIRED TO DRY LOW-RANK COALS

Since it is necessary to heat the coal particles to at least 212°F to remove a substantial portion of the total moisture, the hot gases must furnish heat at a temperature level higher than this temperature. Table 1 shows the calculation of heat and minimum hot gas required to dry average subbituminous coal and lignite. In this example it is assumed that 95 pct of the total moisture is removed with hot gases at 600 and 2000°F, delivering heat above a temperature level of 250°F. No radiation is considered, and the calculation gives the ideal or optimum conditions of drying. The calculations show that

Table 1 . . . Calculation of Heat and Hot Gas Required to Dry Subbituminous Coal and Lignite

	Sub-bituminous	Lignite
Total water removed, pct = D	95	95
Total moisture in raw coal, pct = M_1	24	37
Total moisture in dried coal, pct = M_2	1.6	2.8
Dried coal per lb of raw coal = W_2	0.772	0.648
Improvement ratio = R	1.294	1.542
Moisture removed per lb of raw coal = X	0.228	0.352
Temperature of coal charged to drier, °F	60	60
Temperature of dried coal, °F	220	220
Temperature of moisture vapor from coal, °F	250	250
Latent heat in water vapor Btu per lb of raw coal = 1058 X	241	373
Sensible heat in water vapor Btu per lb of raw coal = 84.2 X	19	30
Heat in dried coal, Btu per lb of raw coal at 0.25 sp. ht. = $W_2(220 - 60)0.25$	31	26
Net heat required to dry coal, Btu per lb	291	429
Sensible heat content of average products of combustion between 250 and 600°F, Btu per cu ft	7	7
600°F gas required to dry coal, cu ft per lb*	42	61
Sensible heat content of average products of combustion between 250° and 2000°F, Btu per cu ft	39	39
2000°F gas required to dry coal, cu ft per lb	7.5	11.0

* Gas volumes expressed at base of 60°F and30 in. Hg.

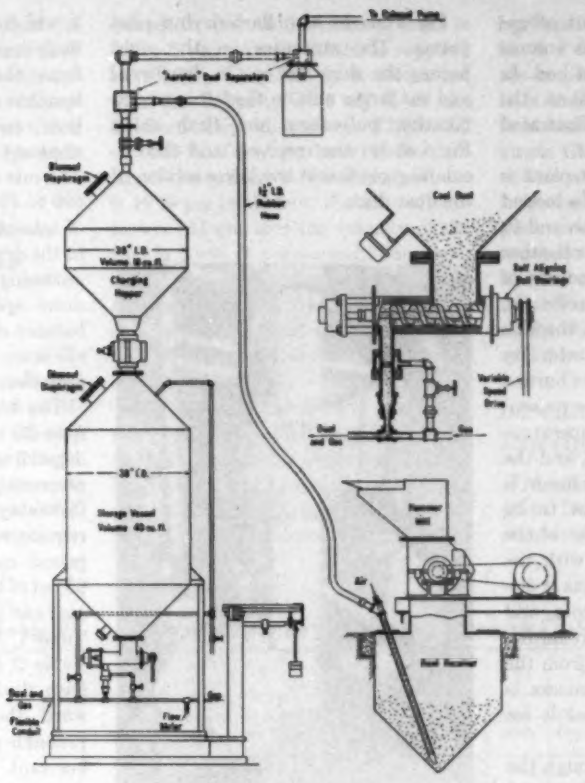

FIG 3—System for preparation, storage, and metering of coal dust.

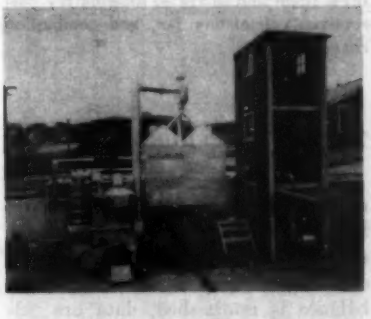

FIG 4—Flash-drying pilot plants, Golden Colo. The structure on right houses flash-drying column for 1/16 in. by 0 coal, and the unit on left is combination pulverizer and flash dryer with capacity of 500 to 800 lb per hour.

average subbituminous coal requires 291 net Btu per pound for drying, while average lignite requires 429 Btu per pound. Furthermore, if waste heat at 600°F is used for drying, 42 cu ft of hot gas is required per pound of subbituminous coal, and 61 cu ft is required per pound of lignite. On the other hand, if the coals are dried with hot gases at 2000°F, only 7.5 cu ft per pound is required for subbituminous coal and 11 cu ft for lignite.

Thus, the limiting conditions for drying low-rank coals are established both as to time and hot gas required. The object of the experimental work was to find out how close these limits could be approached and to work out technical details of handling materials.

Experimental Work on Flash-drying Fine Coal in Suspension

DESCRIPTION OF PILOT PLANT

By referring to Fig 1, it is observed that 1/16 in. by 0 coal particles can be heated in 1.5 to 2.0 sec. The data of Table 1 show that 42 to 61 cu ft of gases at 600°F is required to furnish enough heat for evaporation of 95 pct of the moisture from subbituminous coal and lignite. These limits on time and gas volume indicate that the coal particles must be suspended in and carried by

the hot gas since the amount of gas required is far beyond the gas volume that can pass through a fixed bed. In order to attain these conditions, the pilot plant and equipment illustrated in Fig 2 and 3 were assembled.

The illustration of the pilot plant is self-explanatory. It consists of a looped vertical column 6 in. in diameter and 19 ft in length. A gas combustion chamber supplies high-temperature products of combustion with minimum excess air, and a fan circulates this gas through the column at the desired rate. By regulation of the amount of gas burned and the rate of circulation, any reasonable variation of hot-gas temperature in the column can be attained, and the rate of circulation in the column is under control. Fine coal dust to be dried is introduced at the base of the column and is carried along with the gas to the separators. Excess gas is discarded after the dust separators, and the temperature of the circulating gases is built up with hot gas from the combustion chamber. The process is continuous, but the dried coal is removed intermittently.

Coal is fed to the drier through the pneumatic feeding system illustrated in Fig 3. In this system the coal is prepared to $\frac{1}{16}$ in. by 0 by crushing through a hammer mill and falls into the dust receiver. The coal is moved from this receiver through a flexible rubber hose by suction. The dust is removed by the "Aerotec" cyclone separator above the charging hopper and the air passes on through a clean-up separator to the exhaust pump. The storage vessel holds 1800 lb of dust, which is sufficient for several hours' operation without recharging. Coal can be charged under pressure continuously by introducing the coal through the double valve arrangement on the charging hopper. The fine dust is metered out of the hopper through a screw conveyor, and the rate of feed is regulated by the variable speed drive. The coal dust is then picked up by a jet of inert gas and transported through a flexible tube to the drying unit. Tubes of different diameter are employed for various charging rates. For example, a $\frac{1}{2}$ in. id tube will handle coal rates up to 200 lb per hour, and a 1 in. tube will handle coal efficiently at rates of 300 to 600 lb per hour. Approximately 1 cu ft of gas is required to transport 1 lb of coal dust in this system, and with the sacrifice of some pressure drop in the line, coal can be moved any desired distance.

Fig 4 shows two flash-drying pilot plants. The structure on the right houses the drier for $\frac{1}{16}$ in. by 0 coal and the larger unit on the left is a combination pulverizer and flash drier. Fig 5 shows the receivers and the circulating gas fan in the lower section of the dust drier.

FIG 5—Operating floor of dust flash dryer (right unit in Fig 4) showing dry coal receivers, circulating fan, and combustion chamber.

TESTING PROCEDURE

The drying unit is heated with natural gas several hours before charging coal, and the temperature of the system is regulated to approach desired operating conditions. When thermal balance is established, data are collected to determine normal radiation from the system. The coal is then introduced and the plant operated for a few hours to reach thermal equilibrium. A testing or balanced period then is established, and operating data are recorded. During the balanced period, everything is in equilibrium, and no changes are made. The testing period usually lasts several hours in order to reduce errors to a minimum.

RESULTS OF TESTS AND INTERPRETATION OF DATA ON FLASH DRYING

The operating data and calculations made therefrom are presented in Table 2, which gives the results of 11 tests on flash-drying several coals. As shown from the operating data, coal was handled at rates of 139 to 274 lb per hour, and the percentage of moisture removed D ranged from 54 to 85 pct. The rate of processing coal ranged from 690 to 1360 lb per hour per square foot of column area, and the time of contact in the drying column was 1.2 to 1.8 sec, assuming that the coal travels at the same speed as the gas. The heat-balance data indicate that the thermal efficiency is 85 to 92 pct excluding radiation.

The hot gas used for drying varied from 28 to 50 cu ft per pound of coal, depending upon the conditions and percentage of drying. This compares favorably with the minimum hot gas requirements of 42 to 61 cu ft per pound calculated for the removal of 95 pct of the moisture in subbituminous coal and lignite, as previously shown in Table 1. An examination of the data of Table 2 indicates that the process of flash drying is subject to straightforward thermal calculations and the probable performance of a plant on any low-rank coal can be calculated. It is shown that a substantial portion of the moisture is removed in about 1.4 sec, which is in fair agreement with the theoretical time calculated for Fig 1. For a greater degree of drying, it is indicated that the time of contact will have to be extended by lengthening the column or by decreasing the rate of circulation. The relationship of the several factors affecting the flash drying of $\frac{1}{16}$ in. by 0 dusts with low-temperature gases or waste heat can be estimated from the experimental data of Table 2, and it is believed that enough pilot-plant data are presented to warrant design of larger units for particular conditions.

The rate of circulation of gas given in lines 23 and 25 of Table 2 indicate that hot gases should be circulated at a rate of about 10,000 lb per hour per square foot of column area in order to ensure that the $\frac{1}{16}$ in. particles are swept upward with the gas stream. Experimentation on lower rates of circulation indicated that troubles might arise from the larger particles dropping out.

The chemical analyses of the coals before and after drying are given in Table 3, and the screen analysis of the dried product is shown in Table 4. Measurements were made of the bulk density of the dried dusts which indicated the density by ASTM method

to be about 45 lb per cubic foot and the density after tamping to be about 51 lb per cubic foot. During the drying operation, the coal shrinks almost in proportion to the moisture removed which accounts for the relatively high bulk density of the dried product.

Experimental Work on Drying Coal in the Fluidized State

OBJECT AND SCOPE

In a fluidized bed the gas travels at a much greater velocity than the particles in suspension. If the space velocity in a fluidized column at 300°F is 5 ft per second, the system passes 12,300 cu ft of gas per hour per square foot at 60°F. According to Table 1, the hot gas required to dry subbituminous coal is 7.5 cu ft per pound if the gas is supplied at 2000°F. Therefore it is calculated that the capacity of 1 sq ft of the fluidized bed should be 12,300/7.5 = 1640 lb of coal per hour. If the density of the coal in a 6-ft fluidized column is 10 lb per cubic foot, the time of contact is 131 sec, and the velocity of the coal is 0.046 ft per second. Therefore, in the fluidized system considered in this case, the gas travels at 5 ft per second and the coal travels at about 0.05 ft per second, a difference in rate of 1:100.

According to the data of Fig 1, the time required to heat particles of coal ⅛ in. in diameter is about 6 sec, which is less than one twentieth of the time calculated as available in a 6 ft bed. Therefore it is calculated that ⅛ in. by 0 coal should be substantially dried in a 6 ft fluid bed when hot gases are employed at 2000°F. Furthermore, it is indicated that the depth of the fluid bed might be reduced to 1 ft with ample time of contact to remove most of the water from ⅜ in. by 0 subbituminous coal. The object of the experimental work in the pilot plant was to study the system outlined above and to gain experience in handling materials. Various tests are in progress to study the relationship of the several variables.

DESCRIPTION OF PILOT PLANT AND EQUIPMENT

A schematic diagram of the pilot plant for drying coal in the fluidized state is shown in Fig 6, which is drawn

Table 2 . . . Summary Data on Flash-drying Low-rank Coals

Test number	(1)	3	4	5	6	7	8	9	10	11	12	13
Coal name	(2)	Monarch	Monarch	Monarch	Monarch	Monarch	Monarch	Hanna No. 4A	Wyodak	Wyodak	Elkol	Peacock
Materials and moisture data												
Coal charging rate, lb per hr = W_1	(3)	204.0	196.5	203.0	139.0	190.0	191.0	204.0	147.0	189.0	202.0	274.0
Duration of test period, hr[a]	(4)	6.25	2.50	3.50	3.00	7.00	7.00	13.50	9.80	7.40	16.25	14.10
Inert gas used for moving coal, cu ft per lb	(5)	2.0	2.0	0.9	1.3	1.1	1.1	1.3	1.9	1.3	1.3	1.1
Moisture in raw coal, pct (as charged) = M_1	(6)	24.9	25.2	24.6	25.4	16.4	15.2	11.6	30.8	23.6	20.7	12.1
Moisture in dried coal, wtd. avg, pct = M_2	(7)	12.9	13.4	8.8	4.8	2.7	2.8	4.0	6.1	5.6	4.3	3.0
Dry coal recovered, total lb per hr = W_2	(8)	175.8	169.6	165.4	105.5	160.6	162.8	187.0	108.3	152.9	167.3	246.1
Ratio: Coarse to fine coal in receivers.	(9)	2.30	2.49	7.79	6.13	8.8	7.9	5.5	5.0	4.0	5.9	4.4
Improvement ratio by weight loss = R_w	(10)	1.160	1.158	1.227	1.318	1.183	1.173	1.091	1.357	1.236	1.207	1.104
Improvement ratio by moisture determination = R_m	(11)	1.160	1.158	1.210	1.276	1.164	1.146	1.086	1.357	1.236	1.207	1.104
Ultimate improvement ratio = U	(12)	1.332	1.337	1.326	1.340	1.196	1.179	1.131	1.445	1.309	1.261	1.138
Degree of drying, pct = D	(13)	55.3	54.1	70.6	85.2	85.9	83.9	68.3	85.4	78.0	82.9	72.7
Dust loss, percentage of dried coal = L	(14)	0.0	0.0	1.4	3.3	1.6	2.4	0.5	0.0	0.0	0.0	0.0
Heating system data												
Natural gas used, cu ft per hr[b]	(15)	63.3	63.9	79.8	79.2	75.3	78.4	56.7	73.1	73.1	71.4	62.1
Net heat supplied, Btu per hr.	(16)	55,700	56,200	70,224	69,696	66,264	68,992	49,896	64,328	64,328	62,832	54,648
Air used with gas, cu ft per hr	(17)	698	706	830	837	760	789	570	747	748	738	642
Net heat supplied per lb of raw coal, Btu	(18)	273	286	346	501	349	361	245	438	340	311	199
Analysis of circulating gas:												
H_2O, pct (determined by analysis)	(19)	37.0	35.1	47.4	37.6	39.0	40.5	46.0	56.6	57.5	53.7	49.6
CO_2, pct (determined by analysis)	(20)	5.3	5.3	5.4	6.2	6.1	6.1	5.1	4.8	4.5	4.6	4.7
O_2, pct (determined by analysis)	(21)	4.3	4.7	2.1	2.6	2.7	2.5	2.6	1.8	1.5	2.1	2.5
N_2, pct (determined by analysis)	(22)	53.4	54.9	45.1	53.6	52.2	50.9	46.3	36.8	36.5	39.6	43.2
Rate of circulation of heating gas, cu ft per hr	(23)	6,910	6,030	7,240	6,620	6,894	6,798	8,163	7,230	7,125	7,069	7,627
Air leakage from carbon balance, cu ft per hr	(24)	453	456	593	383	419	439	504	729	832	770	640
Mass velocity of circulating gas, lb per hr per sq ft	(25)	2,283	2,008	2,291	2,187	2,266	2,221	2,594	2,194	2,148	2,146	2,832
Contact time, sec (gas circulation)	(26)	1.5	1.8	1.4	1.4	1.3	1.4	1.2	1.3	1.3	1.3	1.2
Temperatures in system, degree F												
Combustion chamber, Point 1	(27)	1,380	1,530	1,775	1,780	1,815	1,790	1,895	1,760	1,740	1,750	1,902
Inlet to drying column, Point 2	(28)	490	440	595	660	650	680	506	659	608	620	573
Midway in "Up" column, Point 3	(29)	290	265	365	440	405	411	363	418	416	408	373
Top of column, Point 4	(30)	237	212	290	355	360	360	333	355	347	355	352
Outlet of column, Point 5	(31)	230	207	285	345	350	350	327	346	335	348	346
Recirculated gas at fan, Point 9	(32)	216	202	267	316	325	325	307	317	312	318	320
Average of points, 2-3-4-5-9	(33)	292	265	360	425	418	426	367	419	404	410	393
Heat balance												
Radiation, Btu per lb raw coal charged[c]	(34)	150	155	150	220	161	160	150	208	161	151	111
Net heat used, Btu per lb raw coal charged[d]	(35)	220	209	277	358	260	250	183	421	325	303	260
Net heat required to dry coal, Btu per lb[e]	(36)	201	192	245	310	224	213	155	364	278	261	174
Drying efficiency, excluding radiation, pct[f]	(37)	91.4	91.9	88.4	86.6	86.2	85.2	84.7	86.5	85.5	86.1	87.0
Overall efficiency of plant, pct[g]	(38)	54.3	52.7	57.1	53.6	53.2	52.0	46.5	57.9	57.2	57.5	55.9
Unaccounted for heat, Btu per lb coal charged[h]	(39)	96	78	81	76	73	49	88	191	145	143	112

[a] Duration of test period, hr. Actual drying operations were carried out for the time indicated. Heat and material data were obtained for a 3-hr balance period (except for test 4, showing a 2½-hr balance period).

[b] Natural gas used, cu ft per hr. All gas and air volumes reported as cu ft per hr, at 60°F and 30 in. Hg, dry. Natural gas for heating has a gross heating value of 985 Btu per cu ft and a net heating value of 880 Btu per cu ft, 60°/30 in., saturated.

[c] Radiation, Btu per lb of raw coal charged. Based on four separate overnight radiation tests at average operating temperatures, a value of 30,500 Btu per hr was established for the overall radiation from the flash-drying unit when operating without coal feed.

[d] Net heat used to dry coal, Btu per lb (calculated). Represents the heat necessary to evaporate water from coal (at 1058 Btu per lb) and raise the temperature of the vapor from 60°F to temperature of the circulated gas, plus sensible heat in dry coal (at 0.25 Btu per lb per °F) from 60°F to temperature of circulated gas plus sensible heat in products of combustion used for pneumatic coal charging between charging temperature and circulated gas temperature plus sensible heat in wet products of combustion rejected to atmosphere between 60°F and the temperature of circulation.

[e] Net heat required to dry coal, Btu per lb. Same as item 35, footnote[d], but less the heat in the wet products of combustion rejected to the atmosphere.

[f] Drying efficiency, excluding radiation, pct. Defined as the net heat required to dry coal, item 36 (see footnote [e]), divided by the net heat to dry plus the sensible heat in the products of combustion and water vapor, item 35, (circulating gas) rejected to the atmosphere times 100.

[g] Overall efficiency of plant, pct. Defined as the net heat required to dry coal, item 36 (footnote [e]), divided by the total net heat supplied to the drying system by the combustion of the natural gas and any coal dust consumed.

[h] Unaccounted for heat, Btu per lb of coal charged. This is the heat liberated by a small quantity of ultrafine coal dust in the bypassed recirculated products of combustion and burned in the combustion chamber. On the average, it represents a negligible loss of material, assuming the heat of combustion of the fine dry coal dust to be in the range of 10,500 to 11,500 Btu per lb, depending on the rank of coal dried. It is calculated from the following values given in Table 2.

$$\text{Unaccounted for heat, Btu per lb coal charged} = \frac{30{,}500 \text{ Btu} - \text{Item (16)}}{\text{Item (3)}} + \text{Item (35)}$$

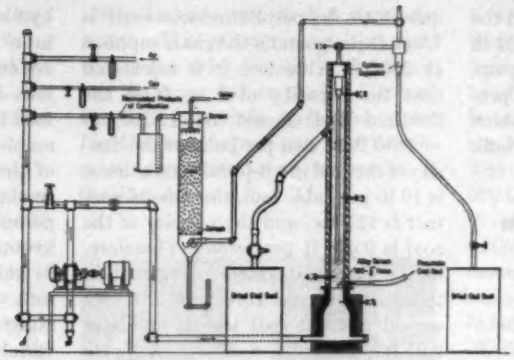

FIG 6—Schematic diagram of fluidized bed drying unit.

to scale. Air, natural gas, and recirculated products of combustion are burned under pressure in the combustion chamber at the base of the column. The combustible mixture is adjusted to generate a temperature of about 2000°F with little excess air. The pump and metering system on the left will deliver any desired quantity of combustible mixture at pressures up to 5 in. Hg. The pilot plant and coal-feeding system is shown in Fig 7.

The products of combustion from the combustion chamber pass through a heat-resisting alloy plate having 160 holes ⅛ in. in size. Coal dust from the metering system previously described and illustrated in Fig 3 enters the column just above the screen and mixes with the hot products of combustion. The bed is fluidized, and the coal moves upwardly to the first offtake and through two dust separators. The dried coal is deposited in the receivers, and the residual gas not entering the recirculating system is discarded.

The drying column is a standard 6-in. steel pipe insulated with mineral wool. Temperatures are taken at 5 points and recorded continuously, and pressure connections are provided at the base and top of the column.

TESTING PROCEDURE

The unit is started by igniting a combustible mixture of air and gas without recirculating products of combustion. When the temperature at point 5 reaches 1700°F, gas recirculation is started and adjustments are made to bring the combustion-chamber temperature to about 1900°F. Coal is then introduced at the desired rate, and adjustments are made to bring the fluidized bed to the selected tempera-

Table 3 . . . Analyses of Coals Before and After Flash-drying

Mine Name[1]	Test No.	Coal Rank	Condition[2]	Analysis, Per Cent									Btu per Lb Coal
				Proximate				Ultimate					
				Moisture	Volatile Matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	
Monarch	3	Sub. B	a	24.9	31.8	39.2	4.1	6.6	53.1	1.2	34.6	0.4	9,130
			b	12.9	36.9	45.4	4.8	5.8	61.6	1.3	26.0	0.5	10,580
Monarch	4	Sub. B	a	25.2	31.7	39.0	4.1	6.6	52.9	1.2	34.8	0.4	9,093
			b	13.4	36.7	45.1	4.8	5.9	61.3	1.3	26.3	0.4	10,528
Monarch	5	Sub. B	a	24.6	31.9	39.3	4.2	6.5	53.3	1.2	34.4	0.4	9,166
			b	8.8	38.7	47.5	5.0	5.6	64.5	1.4	23.0	0.5	11,087
Monarch	6	Sub. B	a	25.4	31.6	38.9	4.1	6.6	52.8	1.1	35.0	0.4	9,069
			b	4.8	40.3	49.6	5.3	5.3	67.3	1.5	20.1	0.5	11,573
Monarch	7	Sub. B	a	16.4	35.4	43.6	4.6	6.1	59.1	1.3	28.5	0.4	10,163
			b	2.7	41.2	50.7	5.4	5.2	68.8	1.5	18.6	0.5	11,828
Monarch	8	Sub. B	a	15.2	35.9	44.2	4.7	6.0	60.0	1.3	27.6	0.4	10,309
			b	2.8	41.2	50.6	5.4	5.2	68.7	1.5	18.7	0.5	11,816
Hanna No. 4	9	H. V. Bit. C	a	11.6	40.1	39.8	8.5	5.7	60.4	1.1	23.8	0.5	10,510
			b	4.0	43.5	43.3	9.2	5.2	65.6	1.2	18.3	0.5	11,413
Wyodak	10	Sub. C	a	30.8	30.1	33.2	5.9	6.7	47.1	0.7	39.0	0.6	7,965
			b	6.1	40.9	44.9	8.1	5.1	63.8	1.0	21.2	0.8	10,908
Wyodak	11	Sub. C	a	23.6	33.2	36.6	6.6	6.2	51.9	0.8	33.8	0.7	8,794
			b	5.6	41.1	45.2	8.1	5.1	64.2	1.0	20.8	0.8	10,866
Elkol	12	Sub. B	a	20.7	33.6	43.0	2.7	6.5	58.5	1.0	30.7	0.6	10,248
			b	4.3	40.6	51.9	3.2	5.6	70.6	1.2	18.7	0.7	12,367
Peacock	13	H. V. Bit. C	a	12.1	38.0	45.9	4.0	5.9	66.5	1.4	21.2	1.0	11,675
			b	3.0	42.0	50.6	4.4	5.4	73.4	1.6	14.1	1.1	12,884

[1] Monarch No. 45 mine, Sheridan-Wyoming Coal Co., Monarch bed, Monarch, Sheridan County, Wyo.
Hanna No. 4 mine, Union Pacific Coal Co., No. 2 bed, Hanna, Carbon County, Wyo.
Wyodak mine, Wyodak Coal & Mfg. Co., Smith-Rawlins bed, Gillette, Campbell County, Wyo.
Elkol mine, Kemmerer Coal Co., Adaville bed, Elkol, Lincoln County, Wyo.
Peacock mine, Colony Coal Co., No. 7 bed, Rock Springs, Sweetwater County, Wyo.
[2] Condition a, as charged to drier; condition b, after flash drying.

ture. Any temperature above 200°F can be maintained in the bed by regulating the amount of heat released or the rate of coal feed. When the system reaches equilibrium and all materials entering are adjusted to constant rates, the testing period is started.

At the start of the test, the dried coal dust receivers are emptied, and the total weight of the coal-charging system is recorded. The unit is then operated several hours under constant conditions, and measurements are made of the rate of flow of all materials, while complete data on temperatures and pressures are recorded. The testing period is ended by reversing the starting procedure. When shutting down the unit, the coal in suspension in the column is determined by quickly shutting off the circulating gas and coal. The coal remaining in the column is then removed and weighed. This measurement is not precise but it has indicated average column densities of 10 to 12 lb per cubic foot.

RESULTS OF TESTS AND INTERPRETATION OF DATA ON FLUIDIZED DRYING

The operating data and calculations made therefrom are presented in Table 5 which gives results from three tests for which complete data were taken. The coal-charging rate during tests 3 and 4 was approximately 1100 lb per hour per square foot which is somewhat under the estimated maximum capacity of 1640 lb per hour. Subsequent tests made on the pilot plant but not reported in this paper have reached capacities of 1500 lb per hour per square foot of column section.

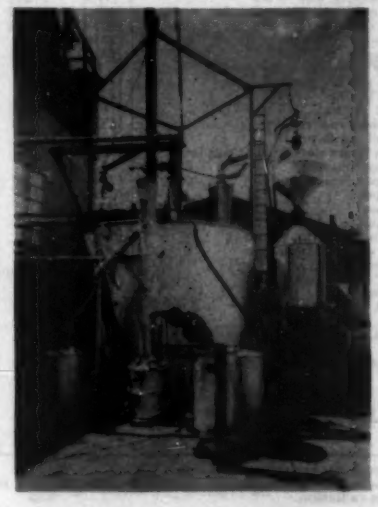

FIG 7—Pilot plant for drying coal in fluidized state. Unit in foreground is 6-in. diam column with drying capacity of 300 lb per hour. Unit on right is coal dust charging system which meters fuel under pressure to pilot plants. The coal dust is transferred pneumatically through flexible conduits.

In test 2, virtually all the water was extracted from the coal since the degree of drying is shown to be 99.1 pct. The dried product from tests 3 and 4 shows that about 94 pct of the moisture was removed, and the total moisture in the dried coal is about 2 pct.

The mean space velocity attained in these tests ranged from 7.5 to 8.8 ft per second, which is somewhat higher than the space velocity of stable fluidized beds. At these high rates, some slugging occurs, and the pressure drop through the column varies from 10 to 20 in. of water but the average pressure drop was approximately 13 in. of water. The mass velocity of the hot gases through the column was approximately 1000 lb per hour per square foot, which is about half the rate employed when drying $\frac{1}{16}$ in. by 0 dusts in the flash drier, reported in Table 2.

The heat-balance data are consistent with the theoretical calculations, which indicates that the probable performance of fluidized drying units operating on any coal may be estimated quite closely. The thermal efficiency excluding radiation reaches 86.5 pct and the overall efficiency, including radiation, is over 75 pct. These efficiencies are to be expected in a small unit, but in a large plant the overall efficiency should be 85 to 90 pct.

The physical and chemical properties of the coal dusts before and after drying are shown in Table 6. It is significant that the bulk density of the dried coal is the same as that of the original coal which indicates that the coal particles shrink about in proportion to the loss of weight. This phenomenon has been observed in other experiments on drying low-rank coals. Since the bulk density of the dried product is the same as that of the original coal, the condensation of potential heat, on a volume basis, is in direct proportion to the weight loss. A carload of dried lignite dust will therefore contain about 45 pct more potential heat than a carload of lignite the same size, while average subbituminous coal will improve about 25 pct in potential heat content per cubic foot. This is significant in reducing freight costs on a potential heat basis.

Table 4 . . . Screen Analyses of Flash-dried Coals[1]

Run No.	4		5		6		7		8	
Sieve, Inch	Retained, Pct	Cum. Retained, Pct	Retained, Pct	Cum. Retained, Pct	Retained, Pct	Cum. Retained, Pct	Retained, Pct	Cum. Retained, Pct	Retained, Pct	Cum. Retained, Pct
(16) 0.0469	0.3	0.3	0.2	0.2	0.1	0.1	0.2	0.2	0.1	0.1
(30) 0.0232	39.5	39.8	38.8	39.0	39.5	39.6	41.1	41.3	34.5	34.6
(50) 0.0117	31.9	71.7	29.4	68.4	29.2	68.8	31.1	72.4	31.1	65.7
(100) 0.0059	12.0	83.7	11.8	80.2	12.9	81.7	13.5	85.9	16.1	81.8
(200) 0.0029	6.4	90.1	9.0	89.2	8.5	90.2	7.4	93.3	9.7	91.5
Pan	9.9	100.0	10.8	100.0	9.8	100.0	6.7	100.0	8.5	100.0
Total	100.0		100.0		100.0		100.0		100.0	

Run No.	9		10		11		12		13	
Sieve, Inch	Retained, Pct	Cum. Retained, Pct	Retained, Pct	Cum. Retained, Pct	Retained, Pct	Cum. Retained, Pct	Retained, Pct	Cum. Retained, Pct	Retained, Pct	Cum. Retained, Pct
(16) 0.0469	0.1	0.1	0.5	0.5	0.8	0.8	0.4	0.4	0.5	0.5
(30) 0.0232	20.1	20.2	34.7	35.2	38.1	38.9	32.8	33.2	32.7	33.2
(50) 0.0117	27.3	47.5	27.3	62.5	22.8	61.7	30.2	63.4	26.8	60.0
(100) 0.0059	19.8	67.3	14.2	76.7	11.0	72.7	16.3	79.7	15.5	75.5
(200) 0.0029	15.9	83.2	11.1	87.8	8.2	80.9	10.8	90.5	9.5	85.0
Pan	16.8	100.0	12.2	100.0	19.1	100.0	9.5	100.0	15.0	100.0
Total	100.0		100.0		100.0		100.0		100.0	

[1] Raw coals crushed to $\frac{1}{16}$ in. by 0 in hammermill. Screen analysis made on composite sample of fine and coarse product from drier.

Acknowledgments

This investigation was carried out under the direction of R. L. Brown, Chief, Coal Branch, Bureau of Mines, and in cooperation with H. G. Fisk and C. C. Boley of the University of

Table 5 . . . Summary Data on Fluidized Drying of Subbituminous Coal

Test Number	(1)	2	3	4
Size of Coal	(2)	¼ in. by 0	¼ in. by 0	⅛ in. by 0
Materials and moisture data				
Coal charging rate, lb per hr = W_1	(3)	157.7	219.0	227.0
Coal charging rate, lb per hr per sq ft	(4)	785	1,090	1,129
Inert gas used for moving coal, cu ft per lb	(5)	1.6	1.2	1.1
Moisture in raw coal, pct (as charged)	(6)	25.0	25.0	21.6
Moisture in dried coal, pct	(7)	0.3	2.0	1.8
Dry coal recovered, total lb per hr = W_2	(8)	116.6	166.5	180.3
Improvement ratio by weight loss = R_w	(9)	1.352	1.315	1.259
Improvement ratio by moisture determination = R_m	(10)	1.329	1.307	1.253
Ultimate improvement ratio = U	(11)	1.333	1.333	1.276
Degree of drying, pct = D	(12)	99.1	94.0	93.4
Dust loss, pct = L	(13)	1.74	0.64	0.49
Heating system data				
Natural gas used, cu ft per hr	(14)	110.8	110.8	109.8
Net heat supplied, Btu per hr	(15)	97,500	97,500	96,600
Air used with gas, cu ft per hr	(16)	1,099	1,099	1,094
Net heat supplied per lb of raw coal	(17)	618	445	426
Hot gas used to dry coal, cu ft per lb	(18)	13.1	9.4	8.9
Products of combustion recirculated, cu ft per hr	(19)	840	840	802
Analysis of gases leaving column:				
H_2O, pct (calculated)	(20)	36.2	41.5	39.7
CO_2, pct	(21)	7.2	6.6	6.7
O_2, pct	(22)	0.8	0.8	0.9
N_2, pct	(23)	55.8	51.1	52.7
Mass velocity in column, lb per hr per sq ft	(24)	972	1,033	988
Mean space velocity in column, ft per sec	(25)	8.8	7.8	7.5
Contact time of coal, sec	(26)	407	289	274
Temperatures in system, °F				
Combustion chamber, point 5	(27)	1,880	1,940	1,910
5 in above screen, point 4	(28)	560	365	380
3 ft, 2 in. above screen, point 3	(29)	540	350	370
6 ft, 11 in. above screen, point 2	(30)	540	350	370
Gas outlet, point 1	(31)	520	335	360
Average bed temperature, points 2, 3 and 4	(32)	545	355	375
Heat balance				
Net heat used, Btu per lb raw coal charged[a]	(33)	543	393	363
Net heat required to dry coal, Btu per lb[b]	(34)	419	340	309
Drying efficiency, excluding radiation, pct[a]	(35)	77.2	86.5	85.1
Overall efficiency, pct[c]	(36)	67.8	76.4	72.5

[a] Total net heat, excluding radiation.
[b] Includes heat used for heating coal carrier gas, excluding radiation.
[c] Includes radiation.

Table 6 . . . Chemical Analyses and Physical Properties of Coal Dried in the Fluidized Bed Drier

Test Number	3		4	
Condition[a]	(1)	(2)	(1)	(2)
Proximate analysis, pct				
Moisture	25.0	2.0	21.6	1.8
Volatile matter	31.3	40.9	32.7	41.0
Fixed carbon	38.3	50.0	40.1	50.2
Ash	5.4	7.1	5.6	7.0
Ultimate analysis, pct				
Hydrogen	6.2	4.7	6.0	4.7
Carbon	51.2	66.9	53.6	67.1
Nitrogen	0.7	0.9	0.7	0.9
Oxygen	36.0	19.7	33.6	19.7
Sulphur	0.5	0.7	0.5	0.6
Btu per lb	8,810	11,510	9,210	11,530
Physical properties. Screen analysis, cumulative pct retained				
On No. 16	15.4	13.3	0.0	0.0
30	46.6	45.3	18.2	17.6
50	71.2	69.8	54.0	53.6
100	85.4	84.0	76.9	75.7
200	94.1	93.2	91.4	89.7
Pan	100.0	100.0	100.0	100.0
Average size, in.	0.0277	0.0265	0.0154	0.0152
Bulk density, ASTM, lb per cu ft	46	46	46	46
Bulk density, impact, lb per cu ft	52	52	52	52

[a] Condition (1) As charged to fluidized drier.
(2) After drying.

Wyoming Natural Resources Research Institute, who conducted experimental work on briquetting the dried dusts.

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Coal Washing in Colorado and New Mexico

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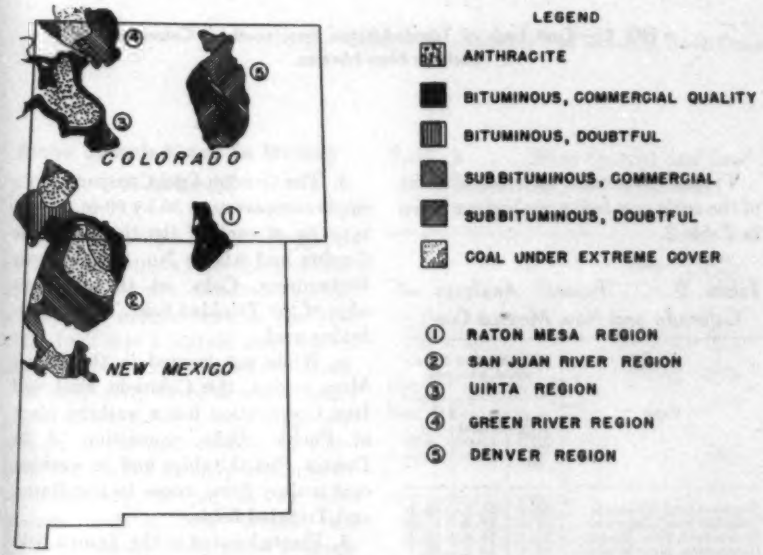

FIG 1—Coal beds of Colorado and New Mexico.

Introduction

In preparing a paper on coal washing in Colorado and New Mexico, it is difficult to refrain from entering into a discussion of the historical aspects of this subject, for the story of coal washing in these states goes back well into the last century. This phase of the subject could well make a complete paper in itself, and of necessity this present discussion must be limited to current operations. Therefore, we are taking into consideration only those washing plants which have operated for some period during the years of 1947 and 1948.

Summary

Of the eight million tons of coal mined in the two states in 1947, approximately two million tons were washed in wet washing plants, using concentrating tables or jigs. The one table plant accounted for 70 pct of the output of washed coal, and two large Baum jig plants accounted for an additional 26 pct, leaving only a small residual tonnage to be accounted for by other types of jigs

The necessity for washing coal is occasioned by the desire or necessity of reducing the ash content of the coals—sulphur is not a problem in this area.

All washeries, except the table plant, are at or near the tipple, hence wash only one kind of coal. At the table plant a large number of different coals are washed. Only at the table plant is there any occasion for drying any considerable quantity of fine coal—other plants size and/or dewater on shaking screens.

The results of washing at the smaller plants are judged by the number (or lack) of complaints about the quality of the washed coal. This is probably as good a system as can be devised for small, intermittent operations.

The efficiency of the Baum jig appears to be quite high. This is to be expected as long as the automatic control of the refuse gate operates properly. The efficiency of the concentrating table is not as high as that of the Baum jig, especially when the "difficulty" of washing is taken into consideration. When dealing with coals in which the "bone" is larger than the "coal," the table appears to be at a definite disadvantage, because of its sizing action.

San Francisco Meeting, February 1949.

TP 2548 F. Discussion of this paper (2 copies) may be sent to *Transactions* AIME before June 30, 1949.

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Where Is the Coal in These States?

It was estimated by Marius R. Campbell[1] that the original tonnage of coal in these two states was as shown in Table 1.

Table 1 . . . Original Tonnage of Coal in Colorado and New Mexico

State	Subbituminous, Tons	Bituminous, Tons
Colorado....	104,175,000,000	213,071,000,000
New Mexico.	172,906,000,000	18,925,000,000

The figure shown for Colorado bituminous coal is larger than that for any other state in the United States, and the figures for subbituminous coal are exceeded only by that for Wyoming. The quantity of commercially minable coal in this area is probably not as large as these figures might be interpreted to indicate; but that is another story.

A map locating the coal beds of these states (Fig 1) shows them as lying in five general "regions."

1. The Raton Mesa region of Colorado and New Mexico, lying across the border of the two states in about a central location and containing the only heavy-coking coal to be found in these states.

2. The San Juan River region, also lying across the border but near the western edge of the states, which contains weakly coking bituminous coals in some areas in addition to a large quantity of subbituminous coal.

3. The Uinta region, lying across the border of Utah and Colorado, also contains weakly coking bituminous coal in certain areas, as well as noncoking bituminous coal and some anthracite.

4. The Green River region, extending from Wyoming into Colorado, contains noncoking bituminous and subbituminous coals.

5. The Denver region, being wholly within the north-central portion of Colorado, contains only low rank subbituminous coals approaching lignite in appearance and quality.

Within each region are a number of fields and districts. Coal washing is, at present, confined to the Trinidad, Raton, and Yampa fields. Taken together, the Trinidad and Raton fields comprise the Raton Mesa region; the Yampa field is on the southeastern border of the Green River region in Routt County, Colo. Fig 2*A* and 2*B* show generalized sections of the coal measures in these two localities.

[1] References are at the end of the paper.

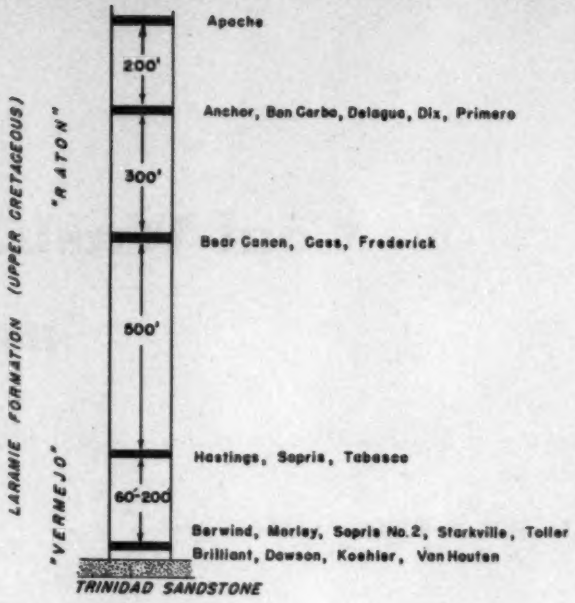

FIG 2*a*—Coal beds of Trinidad-Raton area, southern Colorado-northern New Mexico.

Typical proximate analyses of some of the coals now being washed are given in Table 2.

Table 2 . . . Typical Analyses of Colorado and New Mexico Coals

Field	Moisture-free Proximate Analysis		
	Volatile Matter	Fixed Carbon	Ash
Trinidad field, Colorado...	39.2	51.7	18.1
Trinidad field, Colorado...	31.6	50.8	17.6
Raton field, New Mexico..	35.7	45.6	18.7
Raton field, New Mexico..	35.1	45.2	19.7
Yampa field, Colorado....	41.5	54.5	4.0
Yampa field, Colorado....	41.4	50.8	7.8
Yampa field, Colorado....	40.6	49.1	10.3

Who Is Washing Coal?

The operating coal washeries in the two states are owned by the following companies:

1. The Phelps Dodge Corporation is operating a Link-Belt Simon-Carves 84-in. 2-compartment pneumatic jig at the Stag Canon Branch, Dawson, New Mexico, and is washing Raton field coking coal.

2. The St. Louis, Rocky Mountain and Pacific Company is operating a Jeffrey 84-in. 2-compartment pneumatic jig at the Koehler mine, and is washing Raton field coking coal.

3. The Gordon Fuel Company has a single compartment 36 by 60-in. basket type jig at each of the tipples at the Gordon and Alamo No. 2 mine, near Walsenburg, Colo., at the northern edge of the Trinidad field. This is noncoking coal.

4. While not located in the Raton Mesa region, the Colorado Fuel and Iron Corporation has a washing plant at Pueblo, Colo., consisting of 24 Deister Plat-O tables and is washing coal mainly from mines in the Raton and Trinidad fields.

5. Plants located in the Yampa field (Green River region) of Routt County, Colo., include the Edna Coal Company, operating a 60-in. single compartment Jeffrey diaphragm jig on coal from a strip mine near Oak Creek, Colo.

6. The Moffat Coal Company also operates a 60-in. single compartment Jeffrey diaphragm jig at Routt, Colo.

7. The Keystone Coal Company has a similar jig in operation in the same locality.

8. The Victor-American Fuel Company is operating two plants in the Green River region. At the Pinnacle plant, at Oak Creek, three 30 by 48-in. plunger type jigs of their own design and manufacture are in operation. At the Wadge plant, at Mount Harris, there are two jigs of the same design and size.

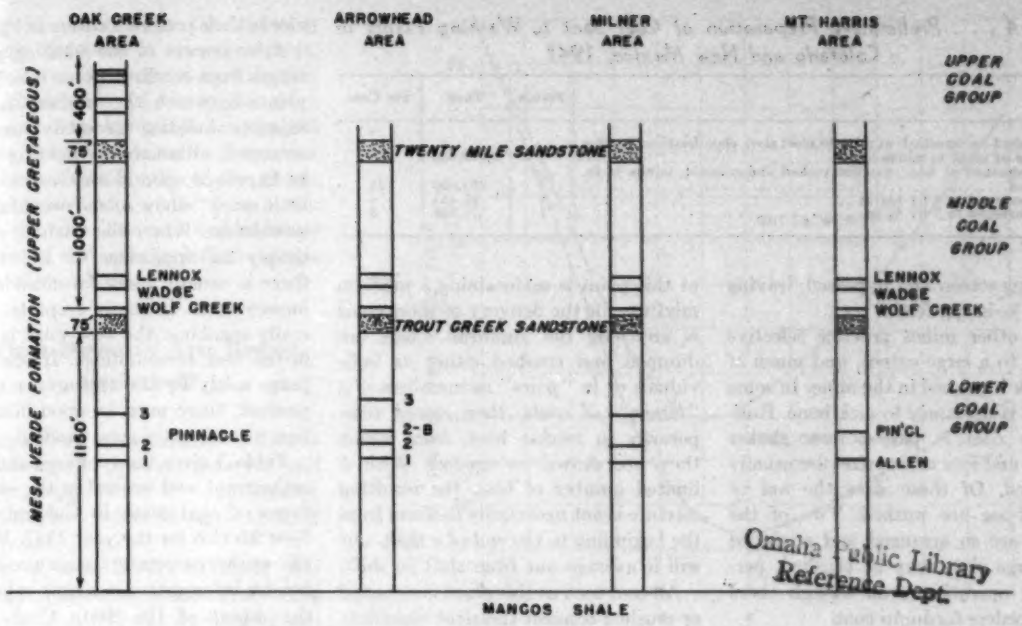

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FIG 2b—Generalized sections of coal measures, Routt County, Colorado.

How Much Coal Is Being Washed?

With a total mine output of approximately eight million tons, the washeries in the two states handled approximately two million tons, in the year 1947. In Table 3 certain statistics on coal mined and coal washed are shown.

In each state there is one washery which accounts for a very large percentage of the coal washed: in Colorado, the Pueblo washery accounts for approximately 95 pct of the coal washed, and, in New Mexico, the Dawson washery accounts for approximately 85 pct of the coal washed. Other washeries are either of small capacity and/or are operated only as market requirements demand.

Why Is Coal Being Washed?

Coal is being washed in these states for two primary reasons:

1. To improve the chemical characteristics of coals used for coke production and other industrial purposes.

2. To improve the appearance and to some degree the quality of free burning coals produced for the domestic trade.

Three of the ten plants are operating on high volatile bituminous coking coal, cleaning coal mined in the Raton Mesa region (see Fig 1). In these plants, in which 96 pct of the coal washed in these states was handled, the necessity for cleaning the coal is increased by the considerable increase in mechanized mining, and, at one plant, by the inauguration of full seam mining. These three plants are, as would be expected, in or fairly close to the Raton Mesa region.

Of the other seven plants, washing only the nut size (3 by 1¼ in.) of coal produced mainly for the domestic trade, two are in the Trinidad field, Huerfano County, and five are in the Yampa field, Routt County, Colo.

All plants are primarily interested in ash reduction, whether actually to improve the chemical quality of the coal or merely to improve its appearance. None of them are particularly concerned with sulphur reduction, the sulphur content of coal produced in these states being so low (seldom exceeding 0.6 pct) that it is necessary to give this impurity but little attention. Because of this fact, this paper will deal entirely with the ash reduction practice of these plants.

Table 3 . . . Mine Output and Coal Washed, Colorado and New Mexico, 1947 Totals

	Tons	Per Cent
Total coal mined:		
Colorado	6,371,132	80.6
New Mexico	1,534,400	19.4
	7,905,532	100.0
Colorado coal to washeries, per cent		15.2
New Mexico coal to washeries, per cent:		
Colorado		31.6
New Mexico		36.3
		67.9
Coal washed in Colorado:		
from Colorado mines	967,333	62.2
from New Mexico mines	484,411	31.1
from Oklahoma-Arkansas mines	103,692	6.7
	1,555,436	100.0
Coal washed in New Mexico:		
from New Mexico mines	556,508	100.0
Total coal washed:		
Colorado	1,555,436	73.7
New Mexico	556,508	26.3
	2,111,944	100.0

What Methods of Preparation Are Being Used?

ADVANCE PREPARATION OF COAL

Nine of the washing plants are located at or near the tipple, and handle coal from the local source only.

The largest of this group of washing plants (Dawson) washes the entire mine output (full seam) with the exception of hand-picked plus 6-in. rock. Run-of-mine coal is dumped by a rotary mine car dumper on 6-in. grizzlies—the oversize is picked and the large coal is crushed to pass 6-in. and returned to the main stream. Just ahead of the jig the minus ⅜-in. is screened out on a

Table 4 . . . Preliminary Preparation of Coal Sent to Washing Plants in Colorado and New Mexico, 1947

	Plants	Tons	Per Cent
Coal crushed (or screened) at mine to meet slack classification. Further crushed at plant to minus ½ in.	1	1,472,953	70
R-O-M screened at 6-in., oversize picked and crushed, minus 3½-in. removed	1	485,000	23
R-O-M screened to 3 by 1¼-in.	7	82,483	4
R-O-M screened to 3 by ¾-in.	1	71,508	3

vibrating screen and bypassed, leaving a 6 by ⅜-in. jig feed.

The other mines practice selective mining to a large extent, and much of the rock is gobbed in the mine. In some cases it is necessary to pick bone. Run-of-mine coal is passed over shaker screens and four or five sizes are usually produced. Of these sizes the *nut* or *nut-and-pea* are washed. Two of the tipples are so arranged and equipped that large sizes may be crushed, permitting operation even though there are no orders for lump coal.

The shaking screens are of various types and sizes. Some are suspended from steel rods, others by wooden "slats," and some are supported by wheels on tracks. All screening surfaces are punched plate. Ordinarily, provision is made to combine several sizes, as desired, either by blanking off the screen or by recombining the screened coal. The crushers, where used at the tipples, are of the single or double toothed-roll type.

One washery is located so that it may be used as a central washing plant for several mines, if that should prove desirable. At present it is equipped with a vibrating screen ahead of the feed bin and bypasses the fines. When the washery was built, sufficient room was left for the installation of drying equipment so that, if necessary, they could wash *nut-slack* or any other "through" size ordered.

The Pueblo plant of the Colorado Fuel and Iron Corp. is a central cleaning plant for a number of coals. Since coals from different sources vary not only in physical and chemical characteristics but are different in coking properties, one of the greatest problems at this plant is maintaining a uniform mixture, for the delivery of these coals is anything but uniform. Coals are dumped and crushed either as individuals or in "pairs" as members of a "family" of coals, then stored temporarily in mixing bins, from which they are drawn as needed. With a limited number of bins, the resulting mixture is not necessarily uniform from the beginning to the end of a shift, nor will it average out from shift to shift.

All coal used at this plant is screened or crushed to meet the *slack* classification of the railroads (minus 1½-in. or minus 2-in.) before loading; but at the plant is further crushed to approximately 85 pct through ½-in. for the purpose of liberating the maximum amount of free impurity.

Table 4 summarizes the preliminary preparation of coal to the washing plants for the year of 1947.

COAL WASHING EQUIPMENT

As previously noted, only two general types of washing equipment were used in this area in 1947: the concentrating table, and the jig.

The table plant has been in operation since 1922 and is beginning to show signs of old age in several places. The Baum jigs are fairly new and apparently still in good shape. They were installed in 1945 and 1946. One of the diaphragm jigs was installed in 1947, and the others are relatively new. The plunger jigs are less than five years old. They are steel duplicates of the worn-out wood-tank jigs they replace. The basket jigs are of uncertain age; but are obviously much older than is indicated by the fact that they were put into service in their present location in 1937.

Arrangement of the washing plants ranges from excellent to terrible. Those plants in which the washery is in a separate building generally are well arranged, although the lighting could be improved upon in some cases, and a little more "elbow room" would not be unwelcome. Where the washing unit is simply an appendage to the tipple, there is usually room for considerable improvement in many respects. Generally speaking, the best work is done in the best surroundings. If one is to judge solely by the appearance of the product, there must be good illumination to turn out a good product.

Table 5 gives the tonnages and percentages of coal washed in the various types of equipment in Colorado and New Mexico for the year 1947. Where the washery operators were unable to furnish information, we have relied on the report of the State Coal Mine Inspector.

HANDLING SUBSEQUENT TO WASHING

The drying of coal at those plants having a sized feed is a comparatively simple matter. Vibrating or shaking screens, provided with a wash spray of clear water, will dewater sufficiently to permit coal to be loaded directly into railroad cars for shipment to the consumer. Such dewatering screens also remove any degradation products, the washed fines being, in some cases, sold as stoker pea. In other cases the washery fines are loaded out with dry slack (which has bypassed the washery).

One plant is so arranged that the washing unit is mounted over loading bins and all sizes of dewatered washed coal are run directly to these bins. Because of this arrangement this plant is able to load out washed coal to either cars or trucks with equal facility.

The dewatering of coal at the table plant, where the coal is more finely crushed, is more difficult. A large portion of the minus ⅛-in. coal is screened out and dewatered on vibrating filters. The coarse coal is passed through a battery of Carpenter centrifugals and then all dried coal is combined and taken to storage bins for charging into the coke ovens. The coarse coal from the Carpenters will average about 7 pct moisture and the fine coal from the vibrators will run about 22 pct, giving a final ⅜ by 0 dewatered product containing about 11.5 pct moisture.

This seemingly high percentage of

Table 5 . . . Coal Washed in Various Types of Equipment, Colorado and New Mexico, 1947

Type of Washer	Number of Plants	Tons Washed	Percentage of Total
Concentrating tables, wet	1	1,472,953	69.74
Baum jig	2	556,508	26.35
Diaphragm jig	3	31,291	1.48
Plunger jig	2	33,102	1.57
Basket jig	2	18,090	0.86
Total	10	2,111,944	100.00

water in the coal to the ovens is actually beneficial in several respects. It results in an increased bulk density and higher net coal charge per oven than any other lower moisture content above 3 pct, retards carbon formation on the roofs and walls of the ovens, and increases the yield of ammonia from the coal. The action of moisture content of coal upon its bulk density is illustrated in Fig 3.

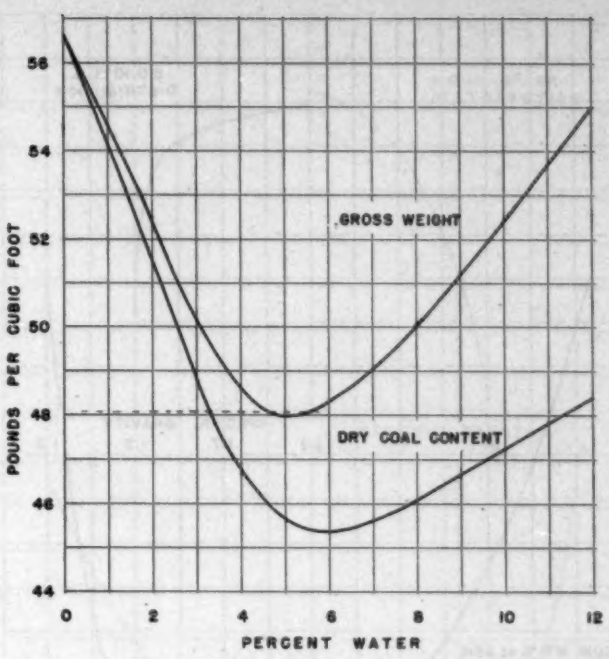

FIG 3—Effect of moisture content on coal weight per cubic foot.

What Results Are Being Secured?

Since there are a number of factors influencing the general conduct of coal washing operations, it would appear advisable to consider certain of these at this point.

One of these factors is largely psychological and may be introduced with the question, "Is the washing of this coal really necessary?" The more convincing the arguments in favor of washing a particular coal the more likely we are to find good results, regardless of the actual equipment used—although we will usually also find better equipment in use than where there is room for doubt as to the necessity of washing. Another intangible factor is tradition or reputation—if a company has managed to build up a good reputation for producing as good a coal as can be found in its territory, it is quite likely that considerable effort will be put forth to maintain this reputation.

On the other hand, we have the more tangible factors of washability characteristics and type of equipment used. Coals of the easy-to-wash type may be cleaned quite efficiently with rather simple equipment and very little technical supervision. The use of elaborate equipment and "quality control" facilities in some of the installations here considered would probably be an economic waste. Other coals probably could well be treated more scientifically than they are with gratifying returns on the investment.

Each washery has its own background and current problems, and it is not our intention to attempt to justify or condemn the various practices we found. Our role is that of observer, not consulting expert.

Samples were obtained from each operating plant; these were all tested and analyzed at one central laboratory.[2] The observations which follow are based on the data so secured and the practice at the various plants will be discussed by geographical groups rather than by individual plants.

HUERFANO COUNTY, COLORADO

The coal washed in this county represents the smallest amount of any of the geographical areas in the two states. Two plants in this county are operated intermittently as market requirements dictate. Samples obtained from the one currently operating plant indicate results on products as given in Table 6. Information as to washery yield and as to character of the feed coal is lacking.

Table 6 . . . Float-sink Data, 3 by 1¼ In. Nut Coal, Huerfano County, Washery A

Specific Gravity	Washed Nut		Reject	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
1.30	13.8	6.9	3.3	5.6
1.38	62.7	9.6	6.2	8.9
1.45	15.4	17.8	4.2	17.5
1.50	4.1	25.0	2.7	24.3
1.60	2.1	32.7	4.4	33.0
1.70	1.4	43.0	3.4	43.6
Sink	0.5	59.6	75.8	78.1
Cumulative ash		12.3		64.3

As in the case of several other washeries, the operation is irregular and not subject to laboratory control. Washing has removed practically all high gravity components from the washed coal and makes it an acceptable commercial product.

ROUTT COUNTY, COLORADO

All of the washeries in this county operate intermittently as the demand for washed nut (3 by 1¼ in.) coal for domestic use may require. Samples of the feed coal and of the products from four of the five plants were obtained and tested in the central laboratory, the fifth plant was idle for a considerable period during the current year. Results on washed coal samples from these plants are as shown in Table 7.

Although each of these plants operates under somewhat different conditions, on feed coal of different washability, and with products of differing quality, one plant only has been selected for discussion and to represent the practice of this county. Data on the feed coal, washed coal and reject from Washery *E* are shown in Table 8.

As previously noted, certain plants in Colorado and New Mexico wash coal mainly to improve the appearance of the product. This is particularly true of Routt County. In the case of Washery *E* the ash content has been reduced from 10.7 to 8.0 pct. This was done principally by the removal of high ash impurity, the sink in 1.6 in the feed coal was 6.6 pct and this was reduced to 1.8 pct in the washed coal. In round numbers, three-fourths of the rock was

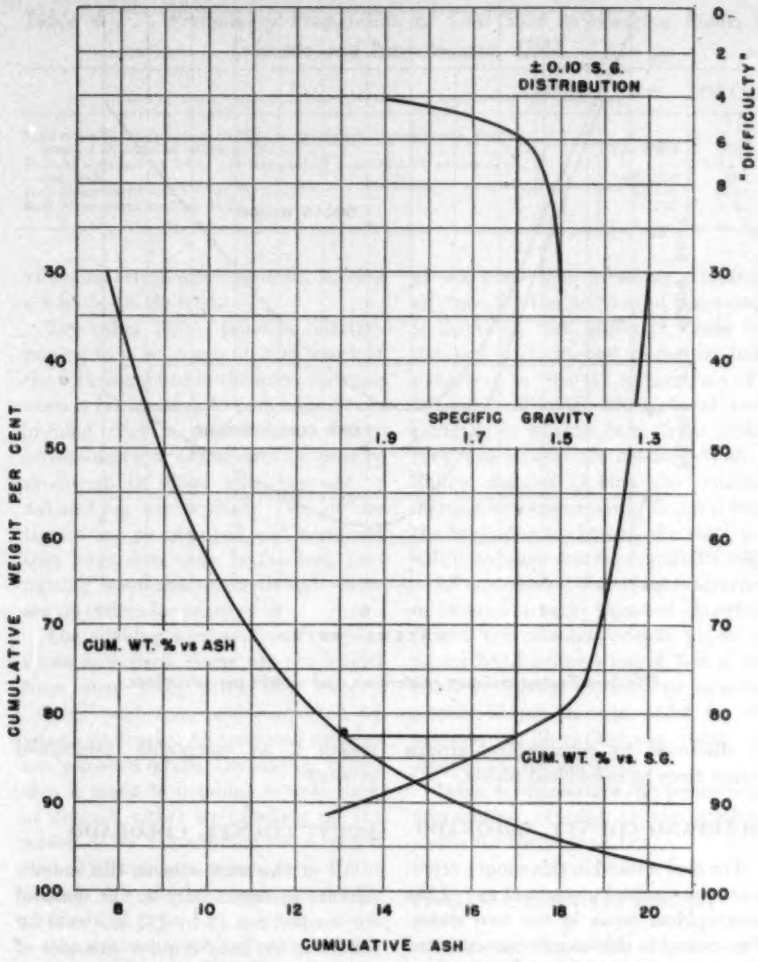

FIG 4—Washability curves, washery *H*, Colfax County, New Mexico.

Table 7 . . . Float-sink Data, Washed Coals, Routt County

Specific Gravity	Washery *C*		Washery *D*		Washery *E*		Washery *F*	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
1.30	79.2	3.5	67.6	3.0	73.2	4.2	84.2	2.6
1.38	15.7	8.9	18.2	10.1	15.8	9.1	5.0	9.5
1.45	1.6	19.3	10.0	14.6	4.0	19.8	2.3	13.8
1.50	2.1	27.3	1.1	27.6	2.9	26.7	0.4	27.3
1.60	0.6	37.0	0.8	34.2	2.3	34.5	0.3	34.6
1.70	0.6	43.5	0.9	45.1	0.4	39.4	0.5	36.4
Sink	0.2	57.2	1.4	69.3	1.4	69.0	7.3	70.4

Table 8 . . . Float-sink Data, Washery E, Routt County

Specific Gravity	Raw Coal		Washed Coal		Reject	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
1.30	72.6	4.2	73.2	4.2	2.3	4.5
1.38	12.5	9.0	15.8	9.1	1.4	9.0
1.45	4.1	19.7	4.0	19.8	0.8	19.5
1.50	3.0	26.7	2.9	26.7	0.9	26.7
1.60	1.2	35.5	2.3	34.5	2.7	35.8
1.70	1.0	41.3	0.4	39.4	2.8	45.5
Sink	5.6	72.2	1.4	69.0	89.1	75.0
Cumulative ash		10.7		8.0		69.7

removed. Apparently this is sufficient to minimize complaints and maintain their position in the market.

With none of these plants washing as much as 20,000 tons of coal per year, it does not appear that it would pay to install laboratory facilities and inaugurate a system of quality control at an individual washery. While exact figures are not available, yields at all washeries appear to be above 90 pct. The coal that might be saved by increased efficiency because of scientific control as compared to visual inspection probably would not be worth enough to warrant much of an increase in expenditure along this line.

COLFAX COUNTY, NEW MEXICO

There are two plants operating in this county, one washing the entire mine output as a matter of routine, the other washing only a portion of the coal on special order. The two situations are not comparable. One mine takes the full seam, and the coal is shot down. The other mine loads rock separately as much as practicable and uses airdox.

At both of these washeries samples were secured which were representative of the different products, as well as estimates of the relative proportions of all components. These individual samples have been combined together as shown in Table 9 as the calculated feed for Washery *H* and in Table 12 as the calculated feed for Washery *J*.

At Washery *H* the 6 by ⅜-in. feed is summarized in Table 9 as to weight per cent and ash content at various specific gravities. The raw coal is screened at 6 in. and the large rock is hand picked, after which the lump coal is crushed to pass 6 in. Just ahead of the jig the minus ⅜ in. is screened out and bypasses the washbox. Note the small amount of float-on-1.3 material, the small amount of middle gravity material and the high ash content of the heavy rock.

The recovery from the Baum jig is 82 pct of washed coal with an ash content of 13.1 pct and 18 pct of refuse with 71.1 pct ash. This indicates an efficiency of 99.4 pct, and represents very good practice. In this discussion "efficiency" is the percentage ratio of washed coal recovery to the recovery possible with a perfect float-sink separation at the same ash content.

Tables 10 and 11 show the float-sink data for the various sizes of washed coal and the reject from the two compartments. These results show the presence of very little heavy gravity material in

any of the washed coal samples and comparatively little good coal in either of the reject samples. It would be difficult to suggest any improvement in this operation.

Table 9 . . . Calculated Feed to Washery H, Colfax County

Specific Gravity	Weight, Per Cent	Ash, Per Cent	Cumulative Weight	Cumulative Ash
1.30	30.1	7.7	30.1	7.7
1.38	30.2	11.7	60.3	9.7
1.45	16.9	20.2	77.2	12.0
1.50	2.6	25.7	79.8	12.4
1.60	2.6	33.3	82.4	13.1
1.70	2.6	45.3	85.0	14.1
Sink	15.0	77.4	100.0	23.6

One of the noteworthy characteristics of this coal is that even after excellent washing it is still as high in ash as many of the eastern raw coals (with careful mining practice). This is true of much of the Raton Mesa coal.

In Fig 4 we show the washability curves for this coal. Note that this coal is being washed at a plus or minus 0.1 sp gr *difficulty* of about 6 pct and that it would be difficult to reduce the ash in the washed coal much further because of the extremely rapid increase in *difficulty*. There is no sharp break in the float-ash curve of the feed coal, although there are such breaks in the curve of cumulative weight vs. specific gravity and the *difficulty* curve.

At Washery *J* in this county the feed is 3 by ⅜ in. and may be one of two types: (1) natural minus 3 in., or (2) modified mine run. Normal operation at this mine sends very little heavy rock to the tipple; but large "bone" is picked before a feed of type 2 is crushed for the washery, hence there is little extremely high gravity material present in the feed coal.

The composite of all products indicates the washery feed is as shown in Table 12. Note the low ash of the material sinking in 1.7, as well as the uniform increase in cumulative float ash.

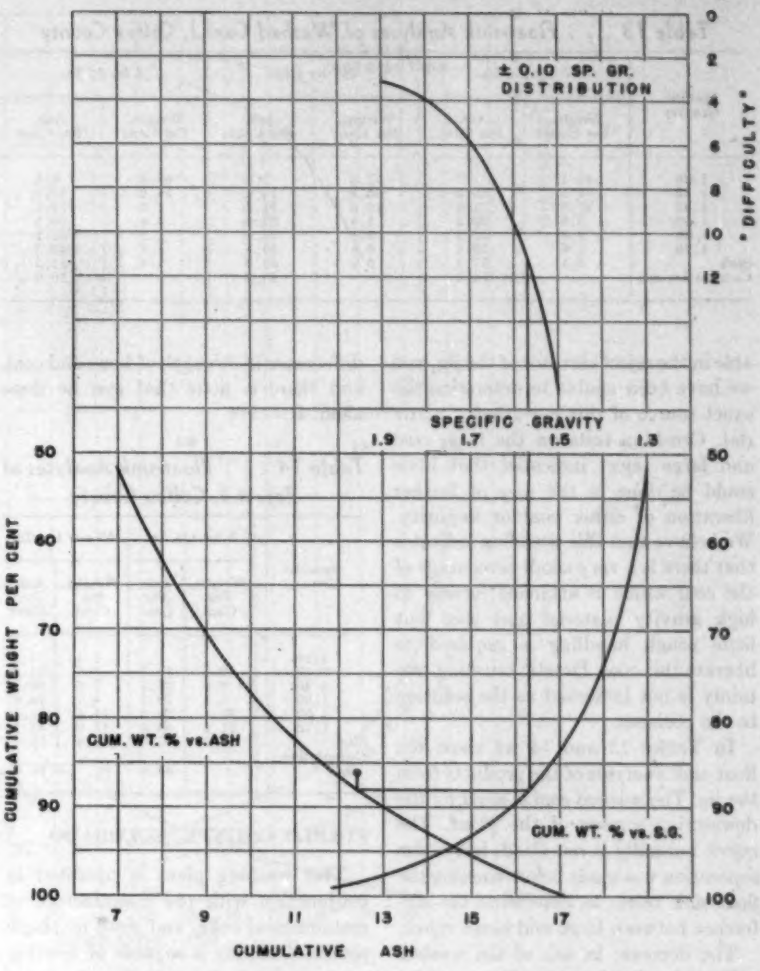

FIG 5—Washability curves, washery *J*, Colfax County, New Mexico.

From this feed a recovery of 86 pct of washed coal of 12.4 pct ash is made. The reject contains only 46.2 pct ash; but the efficiency is 97.7 pct.

The washability curves shown in Fig 5 indicate a much higher *difficulty* than was the case for Washery *H*. In addition to this we find a larger amount of free coal in the minus 1½-in. portion of the reject than was the case for Washery *H*. This condition was not notice-

Table 11 . . . Float-sink Analyses of Reject H

Specific Gravity	First Cell		Second Cell	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
1.30	0.6	8.5	0.1	8.0
1.38	1.3	12.5	0.4	12.5
1.45	1.8	21.0	0.5	23.5
1.50	0.8	28.2	0.3	29.0
1.60	1.1	35.9	3.1	37.4
1.70	3.8	48.0	21.4	45.5
Sink	90.6	81.1	74.2	73.5
Cumulative ash		76.3		65.7

Table 10 . . . Float-sink Analyses of Various Sizes of Washed Coal from Washery H

Specific Gravity	6 by 3 In.		3 by 1½ In.		1½ by 1 In.		1 by ⅝ In.	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
1.30	15.5	7.2	35.2	8.5	62.3	7.1	48.5	7.3
1.38	58.1	10.1	30.6	12.4	25.2	12.8	31.6	12.7
1.45	22.4	20.1	27.3	20.4	5.3	20.4	12.9	20.7
1.50	0.5	27.4	4.4	24.9	2.8	27.0	3.1	26.5
1.60	3.3	31.5	2.3	31.9	3.7	35.0	2.4	34.0
1.70	0.1	37.3	0.1	38.5	0.5	44.7	1.0	40.6
Sink	0.1	47.2	0.1	65.8	0.2	58.2	0.5	57.1
Cumulative ash		12.7		14.3		11.1		12.6

Table 12 . . . Calculated Feed to Washery J, Colfax County

Specific Gravity	Weight, Per Cent	Ash, Per Cent	Cumulative Weight	Cumulative Ash
1.30	51.6	7.0	51.6	7.0
1.38	17.3	14.2	68.9	8.8
1.45	9.8	20.9	78.8	10.3
1.50	4.8	27.3	83.6	11.3
1.60	5.9	34.3	89.5	12.8
1.70	3.5	42.3	93.0	13.9
Sink	7.0	59.7	100.0	17.1

Table 13 . . . Float-sink Analyses of Washed Coal J, Colfax County

Specific Gravity	3 by 1½ In.		1½ by 1 In.		1 by ¾ In.	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
1.30	44.7	7.7	57.6	7.6	69.6	6.5
1.38	29.3	15.0	20.5	14.2	14.0	13.3
1.45	17.5	21.8	10.8	21.1	7.2	19.5
1.50	5.8	28.2	5.9	27.0	3.6	25.5
1.60	2.0	33.5	4.1	34.0	2.9	33.5
1.70	0.6	39.6	0.6	39.5	1.3	40.3
Sink	0.1	57.1	0.5	50.3	1.4	51.5
Cumulative ash		14.3		13.0		10.9

able in the reject elevator of the jig, and we have been unable to determine the exact source of this low-gravity material. Crushing tests on the large coal and large reject indicated that little could be done in the way of further liberation of either coal or impurity. We believe that this situation indicates that there is a very small percentage of the coal which is attached loosely to high gravity material and that but little rough handling is required to liberate this coal. Drastic crushing certainly is not indicated as the solution to the problem.

In Tables 13 and 14 we show the float-sink analyses of the products from the jig. The washed coal is sized by the dewatering screens of the plant. The reject normally is not sized; but a size separation was made before running the float-sink tests, to determine the difference between large and small reject.

The decrease in ash of the washed coal as the size decreases is normal for this coal. No such trend is evident at Washery *H*. Experiments on crushing the 3 by 1½-in. washed coal (and reject) indicated that even though this portion were crushed to pass ¾ in. its washability characteristics would not be improved noticeably. The large material is inherently more bony than the small, which is probably because of differences in strength of bone and coal, and there is little that can be done about it.

Table 14 . . . Float-sink Analyses of Reject J, Colfax County

Specific Gravity	3 by 1½ In.		Minus 1½ In.	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
1.30			3.4	7.2
1.38	0.4	15.7	2.5	11.6
1.45	0.8	25.5	5.4	20.3
1.50	5.5	29.5	4.7	26.6
1.60	36.4	36.0	14.6	32.1
1.70	21.2	43.8	17.0	42.2
Sink	35.7	56.8	52.4	62.8
Cumulative ash		44.6		47.6

PUEBLO COUNTY, COLORADO

This washing plant is operated in conjunction with the manufacture of metallurgical coke, and since no single source of supply is capable of meeting our requirements, coal from a large number of mines is washed—sometimes as many as 15 in a single month, and as many as 40 in the course of a year.

This situation is not at all favorable. There are constant changes in the character of the feed to the washery, not only from day to day; but from shift to shift and quite probably from hour to hour. The use of yearly averages in such a case is inadequate; but can hardly be avoided in a brief discussion.

As an example of the possibility for variation, individual cars of coal 2 in Table 15 have been known to be as low as 18 pct ash and some have been as high as 40 pct ash. Coal 1, on the other hand, is more uniform, the range being about 5 pct in ash. Other coals probably have a range not exceeding 7 or 8 pct with ordinary care in mine preparation. We could, presumably, obtain a fairly uniform mixture if all coals were received daily in the same proportion as ordered for the week; but this is a situation that has not developed yet. The blending system does eliminate the extreme variations; but, because of limited capacity, cannot furnish a truly uniform feed.

Table 15 shows the 1947 average float-sink data on all major coals (1 to 6) and two groups of coals (7 and 8). Coals 1 to 6 are all high-volatile coking coals. Coals 1 and 2 are from the same mine, 1 being screened slack and 2 crushed lump. Coal 3 is from a company-owned mine in the same field but on a different seam. Coals 4, 5, and 6 are purchased from New Mexico mines in the same region, and from the same seam as coal 3.

Group 7 is the composite of about 25 coals from the low-volatile field of Oklahoma-Arkansas. When available in sufficient quantity, this group is used as 10 pct of the normal mixture. A small amount of special coke is made with 25 pct of these coals in the mixture.

Group 8 is the composite of a number of high-volatile coals which are purchased occasionally to meet our tonnage requirements. The greater part of this group is noncoking coal.

Table 15 is made up from the analy-

Table 15 . . . Float-sink Data of Individual Coals Used at Pueblo, Yearly Averages, 1947

Coal	1		2		3		4		5		6		7		8	
Percentage of Mix	26.11		14.03		13.28		13.53		11.10		8.26		7.04		6.65	
Specific Gravity	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
1.30	76.2	5.8	48.7	6.4	53.2	7.3	53.0	6.5	51.2	6.1	56.3	5.8	66.4	3.6	61.0	6.0
1.38	8.0	13.4	14.2	12.6	19.6	14.5	13.6	14.5	16.5	13.2	13.2	12.6	12.4	8.2	16.2	12.4
1.45	3.3	20.2	6.1	20.0	9.3	21.4	7.3	22.2	6.9	21.4	6.4	20.8	4.2	14.3	5.0	19.8
1.50	1.3	27.2	2.5	27.0	3.6	27.4	4.3	28.5	3.7	28.1	4.2	27.1	1.8	20.4	2.6	25.9
1.60	1.3	34.4	3.1	34.0	3.9	34.3	4.9	35.2	5.2	35.0	5.5	33.8	2.2	26.5	2.7	34.0
1.70	1.0	43.1	2.3	42.8	2.6	42.7	3.4	43.4	3.9	43.5	4.4	42.1	1.5	34.3	2.0	43.0
Sink	8.9	74.6	23.1	75.0	7.8	66.9	13.5	66.3	12.6	65.3	10.0	64.7	11.5	69.3	9.6	69.5
Fines[a]	18.5	14.3	16.4	18.7	12.5	18.3	15.4	19.6	12.9	19.3	11.3	16.6	31.0	11.8	16.5	20.2
Cumulative ash[b]		14.1		24.9		17.5		20.3		19.5		17.5		12.9		16.6

[a] Fines percentage is calculated on basis of total sample weight. Float-sink tests are on plus 20-mesh only, and are calculated to 100 pct of coarse material.
[b] Cumulative ash is for total sample, including fines.

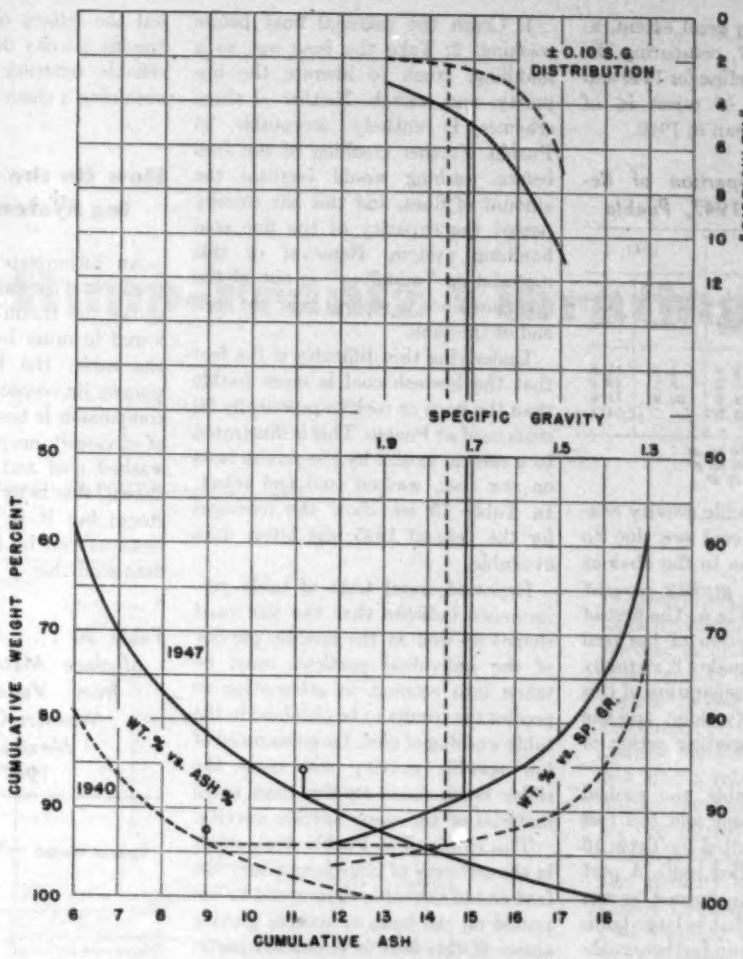

FIG 6—Washability curves, Pueblo coals.

ses of samples taken from the tops of individual cars, according to a regular schedule of proportion of cars of each coal to be sampled and location of sampling points. "General opinion" is that such samples are unreliable; but our experience leads us to believe that this is not necessarily so. The cumulation of all car samples shows an average ash of 17.9 pct as compared to the cumulative ash of 18.1 for all "stream" samples of the mixed feed to the washery. The fines in the two sets of samples are virtually identical at 16.5 pct, and the same is true of volatile matter and sulphur. Any bias in the top samples is, for practical purposes, negligible.

The float-sink data on the average mixture for the year 1947 is shown in Table 16. The usual "separation point" is at approximately 1.7 sp gr, hence the expected ash in the washed coal is slightly more than 11 pct. The cumulation of all washed coal samples shows an ash of 11.2 pct and the yield, corrected to a dry basis, was 85.5 pct of the feed. According to the washability curves of Fig 6 this is an overall plant efficiency of 96.6 pct at a plus or minus 0.10 *difficulty* of 5 pct.

As a matter of interest, we have added to Fig 6 the washability curves for the 1940 coal mixture. It will be noted that the coal was then much easier to wash than it is now. The indicated efficiency was 98.1 pct at a *difficulty* of 2.2 pct.

A part of the decrease in general desirability of the coal mixture is due to the increased usage of the bony coals 4, 5, and 6. However, had the proportion of all the coals in the mixture remained unchanged there would still have been an increase in the difficulty of washing to a low ash: for all coals in use in 1940 have deteriorated noticeably in quality. The total ash has increased considerably, in some cases to as much as 150 pct of the 1940 figure; but this is not entirely due to the inclusion of more "rock"—the float ash at 1.6 sp gr has also increased, with the exception of coal 1.

Table 16 . . . Average Mixed Feed Coal, Float-sink Data for the Year of 1947, Pueblo

Specific Gravity	Weight, Per Cent	Ash, Per Cent	Cumulative Weight	Cumulative Ash
1.30	58.5	6.0	58.5	6.0
1.38	14.0	13.0	72.5	7.3
1.45	6.4	20.6	78.9	8.4
1.50	3.0	27.4	81.9	9.1
1.60	3.6	34.5	85.5	10.2
1.70	2.6	42.7	88.1	11.1
Sink	11.9	70.1	100.0	18.1

The change in washability of the coal has not affected the type of reject

from the tables to any great extent, as is shown in Table 17, comparing the average float-sink of refuse for 1940 and 1947. The quantity of reject is, of course, greater now than in 1940.

Table 17 . . . Comparison of Rejects, 1940 and 1947, Pueblo

	1940		1947	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
Float[a]	4.5	9.9	4.7	11.8
Bone[b]	8.0	27.8	8.5	29.8
Rock[c]	87.5	71.8	86.8	71.6
Head ash		63.8		64.1

[a] Float on 1.38 sp gr.
[b] Float on 1.60 sp gr.
[c] Sink in 1.60 sp gr.

The changes in specific gravity consist of the washed coal are due to two effects in addition to the obvious change in specific gravity consist of the feed shown in Fig 6. The first of these is the sizing action of the coal washing table, which makes it virtually impossible to effect a separation of this coal by specific gravity alone, and the second is the disintegrating action of the centrifugal driers.

As it leaves the table, the washed coal contains more *bone* and less *coal* and *rock* than is indicated by Table 18 (which is based on dried coal). A part of the bone is not homogeneous (as was that at Washery *J*); but is large laminated material which, on further crushing, becomes *coal* and *rock*.

Table 18 . . . Comparison of Washed Coals, 1940 and 1947, Pueblo

	1940		1947	
	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
Float	90.8	6.7	85.4	7.9
Bone	7.3	24.9	10.5	27.0
Rock	1.9	48.1	4.1	50.1
Head ash		9.0		11.2

The usually recommended solutions in such a case are:

1. Crush the material finer before washing. 2. Take the *bone* out as a middling, crush to liberate the impurity, and rewash. Neither of these schemes is entirely acceptable at Pueblo. Further crushing of the feed before washing would increase the amount of fines, and this has already passed the capacity of the fine coal handling system. Removal of this material as "middling" is out of the question since it reports near the feed end of the table.

Underlying this difficulty is the fact that the low-ash coal is more friable than the bone or rock in practically all coals used at Pueblo. This is illustrated to a certain extent by the screen tests on raw coal, washed coal and reject. In Table 19 we show the averages for the year of 1945, the latest data available.

Repeated zonal tests of table performance indicate that the size (and shape) as well as the specific gravity of the individual particles must be taken into account in attempting to predict the results to be obtained in the table washing of coal. Large material of low specific gravity will cross the riffles much more readily than small material of the same specific gravity.

This can, and at Pueblo does, result in the recovery of large *bone* nearer the feed end of the table than would be expected on the basis of specific gravity alone. If this *bone* is laminated material (and no washer can distinguish between homogeneous *bone* and *laminated coal and rock*), subsequent rough handling will separate the layered components, giving the erroneous impression that the process is unable to separate light rock from coal.

With a greater amount of this laminated material in the feed than in previous years, it is not all surprising that there is an increased amount of *rock* in the washed coal. Regardless of the assignable reasons for such a condition, the presence of rock in washed coal is not desirable: but it does point out the fallacy of assuming that the specific gravity distribution alone is a reliable criterion of the difficulty of obtaining a clean washed coal.

Table 19 . . . Size Consist and Ash Content of Raw Coal and Washery Products, 1945

Screen Size		Raw Coal		Washed Coal		Reject	
Through	On	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent	Weight, Per Cent	Ash, Per Cent
	0.525	9.4	27.6	1.9	17.9	16.5	66.0
0.525	0.371	13.8	20.4	5.4	15.7	16.5	66.0
0.371	0.263	13.0	17.1	7.2	13.9	11.0	71.4
0.263	0.131	21.1	14.9	17.4	11.7	14.7	71.4
0.131	0.065	16.1	15.3	19.8	9.6	13.0	65.1
0.065	0.033	11.2	13.7	19.4	8.1	11.8	58.8
0.033		15.4	16.4	28.9	9.2	18.5	58.2

How Do the Various Washing Systems Compare?

An incomplete comparison of the products of the various types of washers shows the Baum jig as the best, followed in order by the diaphragm jig, the table, the basket jig, and the plunger jig, respectively (Table 12). The comparison is based on the proportion of obviously misplaced material in the washed coal and reject. As was just shown, this is by no means the whole story; but it is probably as good a basis as can be found in the limited data available.

Table 20 . . . Comparison of Out-of-place Material in Products from Various Types of Washers, Colorado-New Mexico Practice, 1947 to 1948

Type of Washer	"Rock" in Washed Coal, Per Cent	"Coal" in Reject, Per Cent	Total, Per Cent
Baum jig	1.1	2.3	3.4
Diaphragm jig	1.8	3.7	5.5
Table (wet)	4.1	4.7	8.8
Basket jig	1.9	9.5	11.4
Plunger jig	7.8	8.8	16.6

Conclusion

Each washery has its own particular set of operating conditions and problems—and not the least of these is satisfying the customer. Operations which, at first glance, appear to be "wasteful" or "unscientific" actually may be economically sound for a particular set of conditions. As conditions change, the operator will have no choice but to change his practice or to drop behind those who do. Indications are that the operations covered in this survey will be improved as necessity dictates.

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2. Coke Plant Laboratory. Colo. Fuel and Iron Corp., Pueblo, Colo.

The Rupp-Frantz Vibrating Filter[1]

W. M. BERTHOLF* and J. D. PRICE,* Members AIME

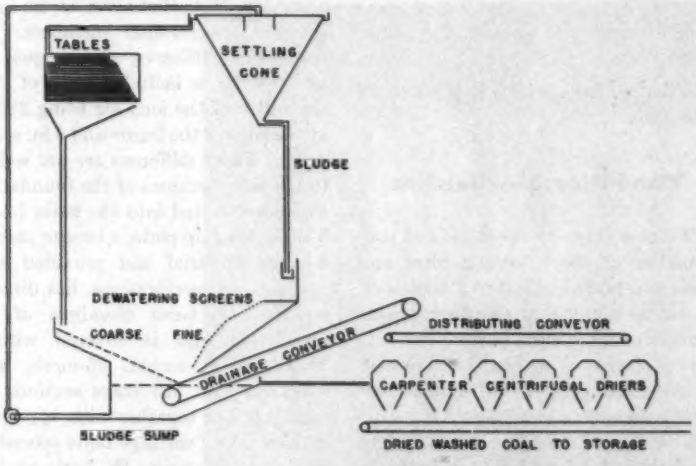

FIG 1—Original layout of washery showing possibility of building up recirculation of fines (sludge).

One of the chief difficulties with which the operator of a coal washing plant has been forced to contend is the handling of the very fine coal. First he has the problem of separating the fine coal from washery water. This is usually accomplished by the use of settling cones or Dorr thickeners: in either event the separated fine coal contains a high amount (40 to 80 pct) of water and, somewhat loosely, dependent upon the size of the coal particles present, may be known as sludge or slurry. His second problem is the satisfactory further dewatering of such separated sludge and/or slurry.

At the coal washing plant of the Colorado Fuel and Iron Corp., washed coal from the Deister Plat-O tables is sluiced to a stationary inclined dewatering screen provided with 3/16 by 1-in. slots, and the coarse coal passing over this screen is conveyed by a Baum-type elevator and a flight-type distributing conveyor to a battery of Carpenter centrifugal driers. The fine coal and water passing through the openings of the primary dewatering screens, plus the fine coal passing through the screens of the centrifugal driers (and no small portion of which is the result of the disintegrating action of these driers) is pumped to two 30-ft Link Belt settling cones. The sludge recovered as underflow from these cones was formerly dewatered on stationary screens having 1/16 by 1-in. slots and discharged on top of the coarse washed coal in the Baum drainage conveyor; but after a relatively few hours of operation the circulating load of fine coal on this conveyor built up to a point where it became necessary to reduce the quantity of feed to the washing tables. The original arrangement of our coal washing and dewatering equipment is shown in Fig 1.

In order to regain the loss in active throughput which had been caused by this circulating load, an installation of six vibrating filters was made during the year of 1936. This resulted in an increase in normal tonnage of washed coal from 1430 to 1750 tons per 8-hr shift, a gain of slightly over 22 pct. This increase in throughput has made a very substantial decrease in the "conversion cost" per ton of washed coal. Since the vibrators were installed, we have gained about 2,000,000 tons in production, compared to what would have been produced in the same number of shifts at the former rate. Putting it in slightly different form, we have saved in the past 12 yr the cost of 1400 operating shifts in the washery.

Fig 2 shows the location of the vibrating filters as applied to the original flowsheet. It will be noted that the sludge from the bottom of the settling cones is passed through a distributing box and thence to the filters. The dewatered coal from the filters is delivered to the conveyor receiving the dried coal from the Carpenter driers.

San Francisco Meeting, February 1949.

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* Efficiency Engineer and Superintendent, respectively, By-Product Coke Plant, Colorado Fuel and Iron Corp., Pueblo, Colo.

[1] References are at the end of the paper.

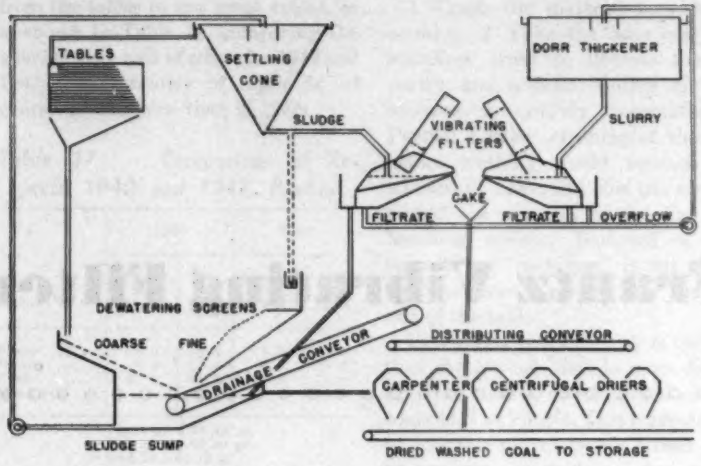


FIG 2—Location of vibrating filters in washery flowsheet. Five vibrators handle sludge, one handles slurry.

By this system the sludge bypasses the drainage and distributing conveyors and the centrifugal driers and the circulating load is minimized. At such times as the filters are able to handle the entire load, there is no material put over the secondary dewatering screens.

Three separate products are taken from the filters, as follows:

1. The filter cake, representing the dried and recovered portion of the feed which, as has been shown, is added to the dried coal leaving the Carpenter driers.

2. An overflow product, which is a "safety valve" discharge from an overflow gate on the filter, provided to prevent overloading of the filter and consequent poor operation. This overflow product is returned to the main system and again pumped to the settling cones, in the case of the five vibrators operating on *sludge*. The overflow from the *slurry* vibrator is returned to the Dorr thickener.

3. The filtrate, or material passing through the screens of the filters, which is pumped to a Dorr thickener on the fourth floor of the vibrating filter structure and from which the settled slurry flows by gravity to a separate but similar filter on the second floor of this structure. Fig 3 shows the arrangement of equipment in this section of the building. Note that the slurry could be added to the total flow of sludge, added to the sludge fed to a single vibrator, or treated separately. We use the last method unless the vibrator in this slurry service is out of commission, and then revert to adding the slurry to the distributor, from which it flows to all vibrators.

The Filter Mechanism

We now come to the details of construction of the vibrating filter and these are shown in Fig 4 to 7, inclusive. It will be noted that the filter proper consists of three main parts:

1. A frame of welded and riveted construction (Fig 4) to support the screen assembly.

2. A screen assembly (Fig 5 and 6) consisting of a foundation, a backing-up plate and a screen wire cloth.

3. An electrical vibrating unit.

The frame proper needs little additional description, beyond the fact that it is made up of $\frac{3}{16}$-in. steel plate, with careful attention being paid to the welding to ensure against failure due to the heavy vibration to which the entire filter is subjected. The frame is supported, or hung, directly from the vibrating unit, this being attached to the frame by the cross members which are securely bolted to the "bull head" of the vibrator.

The screen assembly, shown in Fig 5 and 6, is made up of a foundation composed of a rectangular frame of plate and angles with special stiffening cross members, a backing-up plate and the filter screen proper. Fig 5 is a bottom view of the completed screen assembly. Note that there are no intermediate longitudinal members. The transverse stiffeners are unequal leg angles with an included angle of 135°, the width of the long leg being $2\frac{5}{8}$ in. at the edge of the frame and 5 in. at the center. These stiffeners are arc welded to the side members of the foundation, which are bolted into the main frame. The backing-up plate, a bronze plate of 8-gauge material and provided with $\frac{1}{8}$ by $\frac{1}{2}$ in. perforations, lies directly on the structural members of the foundation and is covered with a Monel metal screen, 35-mesh, with 0.015 in. wire. All three sections are rigidly bolted together with $\frac{5}{16}$ by $\frac{3}{4}$ in. galvanized carriage bolts spaced on $3\frac{1}{2}$ in. centers across the horizontal leg

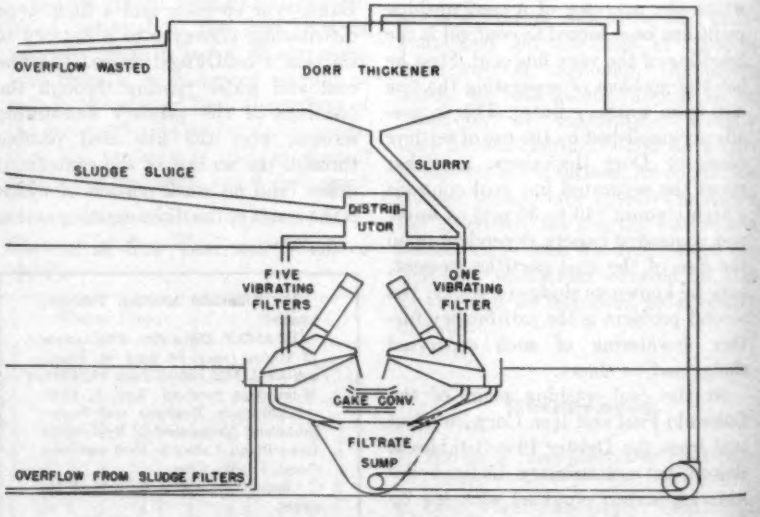
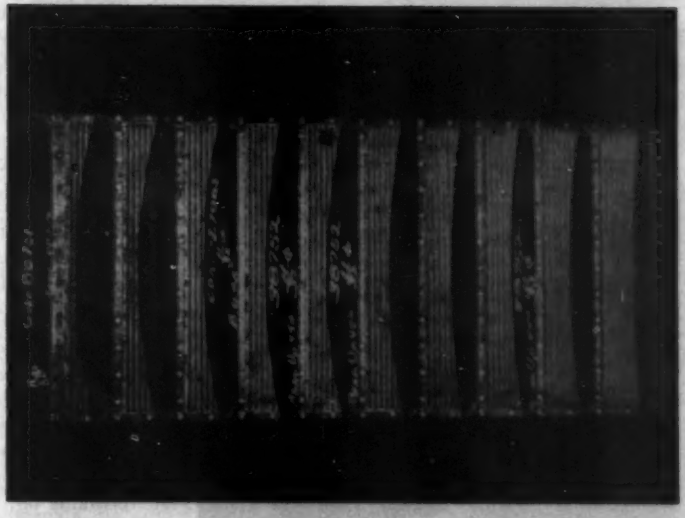


FIG 3—Location of related equipment on four floors of filter structure.



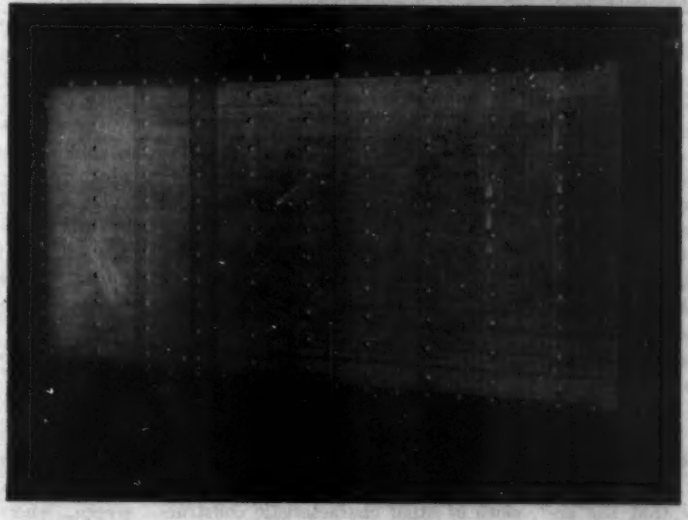


FIG 4—Filter frame. (*Top.*)
FIG 5—Bottom view of completed screen assembly. (*Center.*)
FIG 6—Top view of completed screen assembly. (*Bottom.*)

FIG 7—Filter in operation, view from feed end. (*Top.*)

FIG 8—Filter in operation, view from discharge end. (*Bottom.*)

of each stiffening angle and along the side members of the foundation. Fig 6 shows a top view of the completed screen assembly. The vibrating mechanism is a standard Jeffrey-Traylor unit, No. 5, operated on mixed ac-dc current and rated at 30 amps at 220 v. Fig 7 is a view of the complete assembly from the feed (overflow) end. The complete unit is suspended from the floor above through standard spring vibration absorbing hangers.

While it may appear that the arrangement is cumbersome and that more attention has been paid to detail than should be necessary, in reality every point of design has been arranged for some particular purpose. The slope of the stiffening angles and the large number of assembly bolts are for the specific purpose of preventing secondary vibrations. To secure satisfactory results every part, every square inch, of the complete assembly must vibrate in absolute unison. If any secondary vibrations or harmonics are set up, the machine will fail to operate satisfactorily. Drum-head tension of screen cloth or other characteristic construction details found in many vibrating screens would make impossible satisfactory dewatering of the sludge.

The Filter in Action

Now, let us examine the machine in action. In Fig 7 the sludge is being fed into the vibrator through a pipe and distributing trough. The assembly is so supported that, when under load, the screen bed will incline upward at an angle of about 7° from the horizontal. This arrangement will permit the formation of a pool of sludge up to the overflow gate on the back of the frame and extending about three-fourths of the way up the slope of the screen. In Fig 7 we see the excess feed being discharged through the overflow gate, which is covered by a rubber flap.

When vibration is applied to the machine, things begin to happen. The sludge settles to the bottom of the pool, the vibrating action packs the sludge and squeezes out water, the compacted cake then starts moving up the screen, due to the differential stroke employed, and is compacted further in the process, more and more of the excess water being squeezed out. In the final stage, the cake moves out of the pool, dewatering is completed, and the "dry" cake is discharged as shown in Fig 8, a view from the discharge end. This cake has had its water content reduced to within 2 or 3 pct of that which would be obtained with a vacuum filter. The cake at point of discharge is dry enough and compact enough so that when it extends some distance beyond the end of the screen it will break off sharply because of its weight. If the cake bends to any pronounced extent before breaking off, the operator knows that the unit is not functioning properly. A normal cake is apparently dry and can be handled without wetting one's hands, whereas a poor cake will contain some visible excess water.

The water separated from the sludge is split between overflow and filtrate. Ideal operation would, of course, involve no overflow; but this requires the use of a feed which is difficult to obtain and difficult to handle once it is obtained. We would prefer to operate with a feed containing between 50 and 60 pct solids. Such a feed would eliminate the necessity for overflow and would almost double the tonnage with the same dewatering effect as we now obtain with feeds containing 35 to 45 pct solids. The greater part of the filtrate goes through the lower end of the screen, where there is a considerable depth of pool, and where compaction of the cake has not been fully accomplished.

Some Fundamental Considerations

All of this sounds fairly simple; but there are a number of factors which contribute to its success, the failure of any of which will cause unsatisfactory operation of the machine.

1. The machine must be so constructed and maintained that all parts vibrate in unison. Only by such vibration is the filter cake formed, and it must move as a unit. If for any reason "ribbons," "snakes," or "balls" of sludge are formed, the dewatering action is impaired and the capacity of the machine is seriously reduced. Any secondary vibration, especially between the wire screen cloth and the backing-up plate, will reduce the life of the parts.

2. The coal in the sludge must have such a range or ratio of sizes that it will form a compact cake under the influence of applied vibration. This machine will not function properly on coarse coal or on sludge if there is a serious deficiency in the finer sizes. The situation may be compared to the problem of making a satisfactory concrete. The proportions of gravel, sand, and cement must be properly balanced for good results. While much remains to be learned about the requirements for this particular machine, it appears that material conforming rather closely to the Rosin-Rammler law of size distribution, with a fairly large range of sizes, is capable of being treated with satisfactory results. It certainly is not necessary that the material conform to the theoretical requirements for maximum density of packing which (when dealing with spherical particles) can be obtained only when the size distribution is discontinuous, that is, with components of large, small, and very small sizes but no intermediate gradations.

3. The applied vibration must be of the proper characteristics. Frequency is substantially constant for a given installation, depending upon the alternating current component of the mixed current. Wave form is determined by the relationships between spring-bar tension, the total sprung weight of the mechanism under load, and the wave form of the mixed current. It is the resultant of the magnetic, elastic, and gravitational forces involved. The amplitude is also a resultant of these forces; but in practice is controlled by adjustment of the flow of current to match the load being carried. Too little current will result in a stalled cake and too much current will result in carrying an excess of water up the screen with the coal.

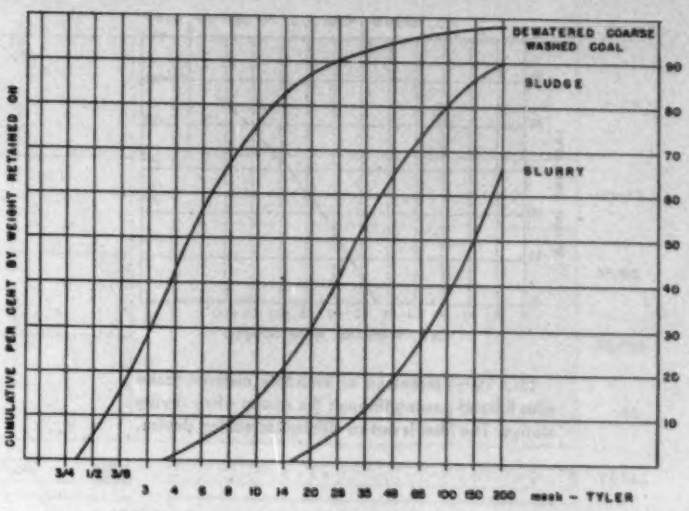


FIG 9—Comparison of various fractions of washed coal.

4. The sludge or slurry fed to the vibrator should contain a reasonable percentage of solids, for the capacity of the filter in terms of dry cake discharged per hour is dependent entirely upon the amount of work the filter must do: and this is (apparently) measured in terms of water to be removed. The smaller the proportion of water which must be handled, the greater the amount of dried cake which can be delivered.

If these factors are kept reasonably constant and within reasonable limits, very satisfactory results can be secured.

Operating Results

Results are, of course, the "proof of the pudding" and may be considered from four angles: (1) capacity of the machine, (2) dewatering effect, (3) distribution of sizes among products, and (4) cost of operation. Each of these appears worthy of separate discussion.

CAPACITY OF THE MACHINE

As has been pointed out above, the capacity of the machine is limited by the amount of water in the sludge. It is also affected by the fineness of the solids. The area of the screening surface and the size of openings in the screen cloth are fairly well established and can be modified only within rather narrow limits. The maximum size of screen which we have been able to operate satisfactorily is 3 ft wide by 6 ft long. Above this size the extra weight of material which would be necessary to ensure absolute rigidity is so great that the useful load is reduced. With the 3 by 6 ft screen, and with a feed containing 40 pct solids, a cake production of 10 tons per hour per unit is regularly secured. If the feed is prethickened to 50 pct solids, the capacity is increased to 15 tons and with a feed prethickened to 60 pct solids, to 20 tons per hour. Since the cake with a normal sludge feed (practically all minus 6 mesh) will contain 20 to 24 pct water, the above capacity figures must be reduced by about 22 pct or to 7.8, 11.7 and 15.6 tons of *dry* fine coal per hour.

The screen cloth must have a certain amount of sturdiness in its own right: it is not possible to use a flimsy screen cloth, even with the large number of bolts used in the assembly. If the screen cloth is too fine or has a very limited percentage of open area, it may not be possible to completely dewater the cake by the time it reaches the end of the filter bed. If the cloth is too coarse, there is an appreciable increase in the fine coal in the filtrate. We have obtained better results with 35 or 40-mesh screen than with any others tried; but the wire must be of sufficient size to make a sturdy cloth and must not be too brittle.

DEWATERING EFFECT

The amount of dried sludge cake delivered by the unit has little, if any, effect upon the moisture content of the cake, and, at an operating rate of 20

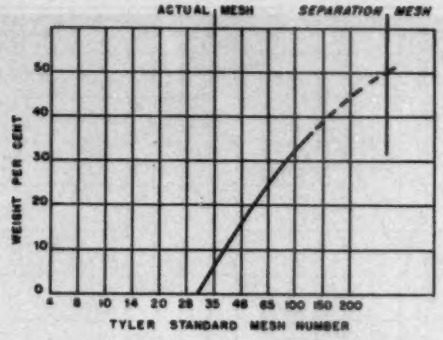


FIG 10—Percentage of available material (cake plus filtrate) passing through the screen when drying sludge. The filter is not an efficient screening device.

tons cake per hour, cake moisture has been recorded lower than with 10 tons output. However, the particle size of the material present in the sludge or slurry does have an important bearing on the moisture content of the final product.

At the Pueblo plant we are dewatering two materials with this equipment, the settling cone underflow, which we call sludge, and the Dorr thickener underflow, which is called slurry. It has already been mentioned that the sludge will nearly all pass a 6-mesh screen. Since the Dorr thickener material is made up solely of the filtrate which passes through the vibrating filter screens, this material is all under 35 mesh in size. The screen analyses of cakes made from these two products is plotted on Tyler standard logarithmic paper in Fig 9, where we have also shown, for comparison, the coarse dewatered coal from the primary dewatering screens. It will be noted that these three materials are widely separated in size and differ appreciably in the proportion of extremely fine material. With so few fines in the dewatered coarse coal, it is easy to understand why there would be difficulty in producing a coke which has most of the water *squeezed* out of it. Many trials were made with this type of material; but it was impossible to obtain a satisfactory cake, and the dewatering action was limited to shaking excess water off the coarsest pieces. Material approximating the screen analysis shown for the sludge cake will form a true cake, from which the greater part of the water will be squeezed out, as will the finer material from the Dorr thickener. As has been noted above, and by others,[3] the retained moisture is affected considerably by the particle size distribution, the greater the amount of fines the greater the amount of moisture retained. For this reason, it is not possible to reduce the moisture content of the slurry cake to the 20 to 24 pct figure quoted for the sludge, its moisture usually being 4 to 5 pct higher. However, a good cake from the slurry vibrator also appears dry on visual examination and may be handled without actually wetting the hands, indicating that practically all excess water has been removed. The capacity of the slurry vibrator is much lower than the sludge vibrators, being approximately one third as great.

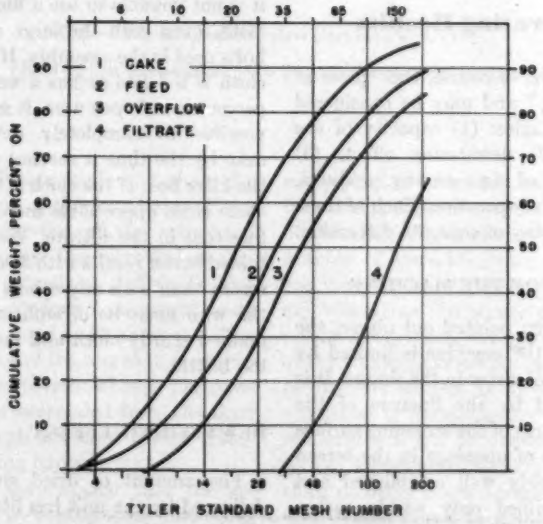


FIG 11—Typical screen analyses of filter products.

DISTRIBUTION OF SIZES AMONG THE VARIOUS PRODUCTS

Here it may be opportune to state that the filter should not be considered as a screen. In fact, it is about as inefficient a screen as might be devised, as is shown in Fig 10, where it will be noted that the actual screen is 35 mesh whereas the 50 pct separation point is in the neighborhood of 270 mesh, that is, half the 270-mesh material remains in the cake and half passes the screen as filtrate. The data for Fig 10 were secured from a test on sludge; but the situation is similar when drying slurry.

The general qualitative situation is shown in Fig 11, where it will be noted that the cake is the coarsest product and the feed, overflow, and filtrate are progressively finer. It is worth noting that the overflow does not carry the very largest particles in the feed—they are able to settle in spite of the rapid current; hence the cumulative curve for the overflow starts at a point to the right of the maximum particle size present in the feed. The cake curve is "deformed" and rises above the feed curve, even though both start at the same point. Normally the filtrate can contain nothing larger than the nominal mesh of the screen, hence its curve should start at about 35 mesh. The presence of oversize is an indication that the screen is torn.

Fig 12 shows the distribution of the various sizes in the feed both as a percentage of the total solid feed and as distributed among the products in a manner similar to the familiar Han-

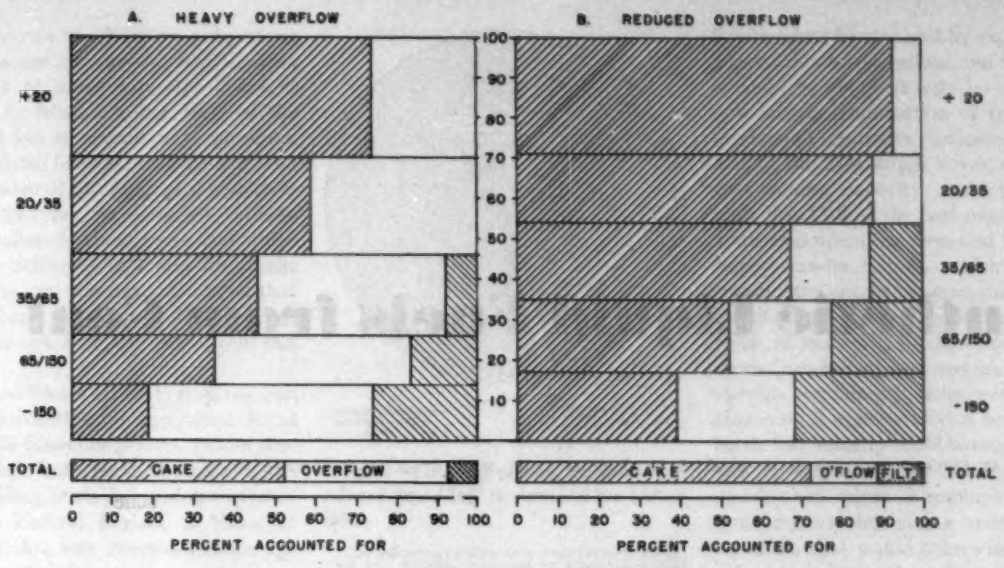


FIG 12—Distribution of various sizes in feed among filter products.

cock diagram for distribution of ash in coal. Two conditions are shown, (*a*) operation with a heavy overflow, and (*b*) operation with a reduced overflow. The reduced overflow was secured by reducing the feed until only a small amount of overflow persisted; but not sufficient to reduce the cake tonnage appreciably. The reduction in the feed rate was about 42 pct and the reduction in the cake tonnage was about 20 pct. There are slight differences in the size composition of the two feeds; but we do not believe they are sufficient to cause any noteworthy difference in behavior. For the two tests there is very little difference in the net recovery of "available" solids, the percentage of such solids in test *a* being 88 and in test *b* being 87. In both tests there is a complete recovery of material coarser than the screen, and a decreasing recovery as the size decreases.

The provision for overflow is intended to prevent the building up of an excessive load in the lower end of the filter, a condition which could result from surges in the feed rate. In practice it has a legitimate function in permitting the operator to feed the filter at a rate slightly above normal capacity, the excess being recirculated and the "net feed" remaining constant at an acceptable rate. Operation along these lines is satisfactory; but when the operator believes that the overflow is intended to save him "trouble" (paying attention to what is going on) it is possible to over-do a good thing. He can then open the feed cock and let the vibrator take care of itself the remainder of the shift. Since a thin sludge will flow much more readily than a thick sludge, there is a tendency to feed the vibrators "too much and too thin"; and the results are not up to standard.

COST OF OPERATION

It will be recalled that in describing the construction details of the filter it was pointed out that a bronze backing-up plate and a Monel woven wire screen were used. These have been adopted after trials of many other materials and have shown longest tonnage life and lowest cost per ton. A further reason for the choice of these materials is found in the necessity of using nonrusting metals: steel has been found unsatisfactory. It should also be mentioned that, in order to retard rusting action, the screen foundation and the fastening bolts are galvanized. Emphasis must be placed upon the need of frequent inspection and prompt repair if maintenance costs are to be kept low. This is particularly true of rips or tears in the screen cloth proper: if neglected, coal will work under the screen and greatly shorten its life.

Based on operating experience on six filters over a period of more than ten years, average life of parts and cost of operation are shown in Tables 1 and 2.

Table 1 . . . Useful Life and Cost of Filter Components

Item	Life, Tons	Initial Cost	Cost per Ton
Main frame	100,000	$25.00	$0.0003
Screen foundation	40,000	50.00	0.0013
Backing-up plate	250,000	75.00	0.0003
Screen cloth	15,000	50.00	0.0033
Total replacement material cost, per ton cake			$0.0052
Current maintenance material cost, per ton cake			0.0028
Total maintenance and replacement material cost			$0.0080

Table 2 . . . Operating Cost per Ton of Dry Coal Handled

Operating labor	$0.0220
Supervision	0.0055
Maintenance material	0.0080
Maintenance labor	0.0100
Electric power and light	0.0020
Total operating cost	$0.0475

Conclusion

The Rupp-Frantz vibrating filter is not an ordinary dewatering screen, many types of which have been tried in this same service with indifferent results. The design and operating features which we have stressed are fundamental, and when all requirements are met, this piece of equipment fills a long-recognized vacancy in the field of coal washing apparatus.

References

1. U. S. Patents 2089548 (1937) and 2183896 (1939).
2. J. M. DallaValle: Micromeritics. Chap. 11, pp. 213–222. Pitman.

Synthetic Liquid Fuels from Coal

By J. D. DOHERTY,* Member AIME

That America's great coal deposits eventually will be our principal source of liquid as well as solid fuels is generally accepted. Moreover, the day when synthetic oil from coal will begin to supplement our petroleum supplies does not appear to be far off.

The American petroleum industry has not spared effort or expenditure in its attempt to keep pace with the demand for oil, and recent production has exceeded expectations. However, the rapidly rising demand for liquid fuels plus the increasing difficulty of finding and developing the new oil needed even to maintain present production rates make it highly unlikely that oil from domestic wells can fully meet future oil requirements. Therefore, it appears that one or more of the following courses must be followed:

1. Curtail oil consumption.
2. Incr ase imports.
3. Develop new sources such as synthetic liquid fuels.

All three courses may well be needed, as it is doubtful that any one of the three alternatives alone can satisfactorily solve the problem indicated by the prevailing trend in demand for oil.

Curtailment of oil consumption is not a constructive policy, except where oil is being wasted or coal can be readily substituted as in stationary steam plants. Reduced oil supplies for most uses will curb our economic advancement and, in addition to inconveniencing consumers, will have a pronounced adverse effect on American industry. The oil-burner-manufacturing industry already has been dealt a hard blow. Shipments in the first 5 months of 1948 decreased 70 pct from those in the same period in 1947.[1] The effect of a similar cut in the automobile industry can be imagined. A severe prolonged shortage of gasoline could seriously disturb our present economic well-being. It might be pointed out also that even the prospect of a shortage or lack of assurance for the future can discourage buyers of equipment, as occurred in the case of oil burners.

An increase in our imports of oil seems to be a necessary expedient for the immediate future. Its advantages are that it will require a minimum of manpower and steel in a time of critical shortages and will conserve domestic reserves. Any major dependence upon foreign sources for our oil supplies should be avoided, however. Other nations are increasing their oil consumption more rapidly percentagewise than the United States and eventually will compete with us for the not unlimited world supplies. In peacetime, foreign countries might restrict shipments of oil to this country or impose exhorbitant prices. In the event of war, there is serious danger that such sources would be cut off, and American-developed oil fields overseas might even be used against us.

Although synthetic fuels cannot relieve any oil shortage that might develop within the next year or two, an immediate start toward a substantial synthetics industry to supplement petroleum not only could help relieve shortages several years hence but also would help establish the much needed "know-how" for large-scale production. By assuring ample future supplies, such a start would permit sound planning by industries dependent upon oil and maintain or restore the confidence of prospective customers for oil-consuming equipment.

If it is agreed that domestic production of crude oil cannot be expected to meet future domestic demands, that oil rationing in general is undesirable, and that too great dependence on foreign oil should be avoided—and the weight of the evidence supports such conclusions—it is inescapable that commercial synthetic fuel production should be developed to supplement domestic petroleum supplies, which, of course, will furnish the bulk of our requirements for years to come.

White Sulphur Springs, November 1948.

Paper presented at Joint Fuels Conference of Coal Division AIME and Fuels Division ASME.

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Assistant Chief, Office of Synthetic Liquid Fuels, Bureau of Mines, U. S. Department of the Interior, Washington, D. C.

[1] References are at the end of the paper.

Sources of Synthetic Oil

The three principal sources of synthetic oil are natural gas, oil shale, and coal. A commercial plant using natural gas is under construction, and expansion of this industry is expected.

However, as the Nation's natural-gas reserves are not much larger than its reserves of crude oil on a basis of weight or heating value, most of the natural gas is committed to pipelines, demands for fuel gas are increasing, and the number of Btu's in fuel of high form value that can be delivered through gas pipelines is about twice that which can be delivered in liquid fuel made from the gas, it is not anticipated that more than a few percent of our gasoline requirements ever will come from this source.

United States oil-shale reserves contain recoverable oil equivalent to at least 125 times our present annual consumption; and, partly because of the low mining costs being demonstrated by the Federal Bureau of Mines at Rifle, Colo., this alternate source appears to be the most promising economically for large-scale oil production. Large as these deposits appear, however, they are small when compared with the country's coal reserves. Furthermore, economically favorable deposits of shale are concentrated in Colorado, Utah, and Wyoming, some distance from the largest markets, and shale is best adapted to the production of heavy fuel oil, hydrogenation or special refining being required for large yields of motor fuel. For these reasons the production of Diesel oil and gasoline from coal is likely to be developed simultaneously with shale oil.

Coal is by far the leading potential source of oil in the United States. Fig 1 indicates the quantities of oil that can be produced from estimated United States reserves of petroleum, natural gas, oil shale, and coal. The accuracy of the geologic estimates of coal reserves has been questioned, and they are being revised constantly. However, a glance at the chart will show that no reasonable revision could alter the conclusions that coal is our outstanding fuel reserve and that coal can furnish oil at present rates of consumption (2 billion barrels per year) for centuries to come.

Suggested Program

To meet anticipated increases in domestic consumption of liquid fuel, it has been suggested that plants be built within the next 10 years to produce 2 million barrels of synthetic oils per day from coal, oil shale, and natural gas. Assuming that half of this production, or 1 million barrels per day, would

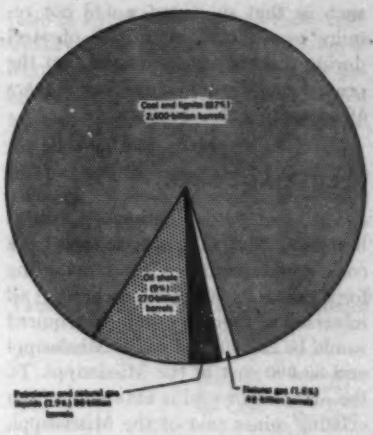

FIG 1—Estimated proved, indicated, and inferred liquid fuel resources of the United States.

The following factors were used for conversion: *Coal and Lignite*—Tonnage of bituminous coal (13,000 Btu per lb) equivalent to total estimated reserves as given by Fieldner (*Mech. Eng.*, March 1947, p. 221); recovery in mining, 50 pct; liquid fuel equivalent—1 ton bituminous coal equals 2 bbl liquid products. *Oil Shale*—Beiser's estimate of assay yield of oil in place in Colorado (Amer. Inst. Min. and Met. Eng. TP 2358; *Petr. Tech.*, May 1948) reduced 25 pct for mining losses, and Winchester's estimates of recoverable oil in other States (Append. I of Fed. Oil Conservation Board Report II, 1928). *Petroleum and Natural Gas Liquids*—Based on L. G. Weeks' "Ultimate Petroleum Reserve" estimate of 110 billion barrels of crude oil for the United States (*Bull. Amer. Assn. Petr. Geol.*, June 1948, p. 1094), less 35 billion barrels produced to date, plus 11 billion barrels estimated ultimate remaining potential of natural gas liquids. *Natural Gas*—Calculated on the assumption that the remaining ultimate potential reserves of natural gas are in the same relation to A.G.A. proved reserves of natural gas as the estimated remaining ultimate potential reserves of oil computed from Weeks' estimates are to the A.P.I. proved oil reserves; liquid fuel equivalent—12,000 cu ft equals 1 bbl liquid products.

Other uses of coal and natural gas and refining losses of petroleum and oil shale have been neglected.

be produced from coal, the effect of such a coal-to-oil program can be estimated. For the purpose of this paper it will be assumed further that oil from coal will be produced equally by the gas synthesis (Fischer-Tropsch) and coal hydrogenation processes and that half of this production will be from coal east of the Mississippi River and half from coal and lignite west of the Mississippi River.

COAL REQUIREMENTS

Bureau of Mines estimates that, for this oil production, 575,000 tons of coal and lignite would be required per calendar day, or a daily output of 805,000 tons when operating mines 5 days per week. This amounts to 210 million tons per year, a 34 pct increase over 1947 production. Of this consumption, 213,000 tons per day would be bituminous coal mined east of the Mississippi River and 362,000 tons would be coal and lignite mined in the west. Some of the western coal and lignite might be obtained by expanding present mining operations, but most of it could be obtained only by opening new mines. Examination of the coal-production statistics indicates that, east of the Mississippi River, existing coal mining capacity could produce most if not all of the coal required by additional operating days and by continued mechanization, which is increasing the output per man-shift. This increased production naturally would result in more rapid exhaustion of reserves in existing mines and necessitate opening new mines at an increased rate. However, it appears that a large synthetic fuel industry could be established east of the Mississippi River without opening new mines or employing additional miners, thus saving construction materials that would otherwise be required for mines and employee housing.

CAPTIVE VS. COMMERCIAL COAL

If the synthetic fuel industry were established entirely with captive coal mines—the plants taking the full production of the newly opened mines—it might have little or no effect on the commercial coal industry. Synthetic fuels operations would provide a market for mining machinery and employment opportunities for mining men, but if no coal were purchased or sold, it would have no more effect on coal trade than the captive mines of the U. S. Steel Corp. and its subsidiaries.

On the other hand, if the synthetic industry is established on the basis of purchasing coal from existing mines wherever possible, the coal industry would be provided with a desirable new market for its product. Synthetic fuel plants as now conceived could use almost any size of coal and would consume it at a uniform rate throughout the year. In practice the requirement of uniform quality and the need for low transportation charges might restrict the purchases of any one plant to a small number of nearby mines.

Legislation to encourage synthetic liquid fuel plants by amending the Internal Revenue Code, introduced in the last session of Congress (S. 2372, S. 2373, H.R. 6008, and H.R. 6495, 80th Congress), would strongly encourage captive production for synthetic fuel plants, as such legislation, if approved, would permit accelerated amortization on all facilities acquired for producing synthetic fuels and would permit an increased depletion allowance on coal mined for this purpose.

CAPITAL INVESTMENT

For producing liquid fuels (90 pct gasoline) by the gas synthesis process, it is estimated that a capital investment of $8500 per daily barrel would be required. Coal hydrogenation would require an investment of $9000 per daily barrel for a plant to produce equal parts of gasoline and distillate fuel oil. For greater gasoline production, the capital investment would be only slightly higher. (A plant to produce chiefly fuel oil from oil shale can be erected for an investment of only $3000 per daily barrel.) These estimates include the investment required for mines and for product pipelines where the plants are away from markets large enough to absorb the products. To produce the proposed 1 million barrels per day from coal and lignite would require a total investment of 8.7 billion dollars. This is a tremendous amount of money, but it can be compared with the capital investment of 7.5 billion dollars that the petroleum industry anticipated would be spent on domestic production, transportation, refining, and marketing facilities in the 5 years from 1947 to 1951, chiefly to maintain present production rates with an expected increase during the period of only a few hundred thousand barrels a day.[2] Actually, about 2¼ billion was expended by the industry for new facilities in 1947 alone.[3]

STEEL REQUIREMENTS

An objection raised against the erection of commercial synthetic fuel plants is the large tonnage of steel required. Recent estimates show that, actually, the steel required for new liquid-fuel capacity from oil shale may be less and from coal little if any greater than that required for increased production of petroleum. It has been estimated that 6 to 7 tons of steel are required for each daily barrel of new petroleum capacity, including production and refining.[4,5] The estimated steel required for synthetic gasoline from coal is 6.4 tons per daily barrel for all facilities, including pipelines to markets. Oil-shale plants to produce chiefly fuel oil have the lowest steel requirement—only 3.4 tons per daily barrel.

The steel required to produce 1 million barrels of liquid fuel per day from coal and lignite, assuming that coal east of the Mississippi would be obtained from existing mines, is estimated at 6,300,000 tons.

It should be noted that a program such as that suggested would not require appreciable quantities of steel during the first two years and that the peak demand would come 5 or 6 years after starting the program.

OPERATING FORCE

The assumed production of 1 million barrels per day of synthetic fuels from coal would require a total operating force of 160,000 men, including all miners. The number of miners required would be 20,000 west of the Mississippi and 33,000 east of the Mississippi. To the extent that coal is obtainable from existing mines east of the Mississippi, new miners would not have to be trained.

PRODUCTS

Coal-to-oil plants for which the foregoing estimates were made would produce daily the following quantities of standard products, which could be distributed through existing channels and which would meet current specifications:

	Barrels Per Day
Liquefied propane and butane (L.P.G.)	86,000
High-grade motor gasoline	648,000
Diesel oil and furnace oil	266,000
Total	1,000,000

It will be noted that this program does not provide for any heavy fuel oil. It is anticipated that fuel oil can be obtained more cheaply from shale and that the shale oil will be distributed to both the west coast and the Chicago area. Heavy fuel oil on the east coast will continue to be obtained from domestic and heavy Venezuelan crudes. Although the product distribution of the gas synthesis plant now under construction is rather inflexible, being approximately 90 pct gasoline (or gasoline plus L.P.G.), the coal hydrogenation process is extremely flexible and can readily produce a high percentage of aviation gasoline, Diesel fuel, jet fuel, or fuel oil, as desired. This factor would favor coal hydrogenation plants for national defense as, in an emergency, aviation fuel requirements undoubtedly would skyrocket. However, some of the gas synthesis primary products can be used in the production of aviation gasoline, and greater flexibility is to be expected for this process in the future as the result of new developments. L.P.G. from the coal hydrogenation process can also be converted to high-test gasoline if desired.

COSTS*

It is estimated that the gas synthesis process using coal can produce 90 pct gasoline and 10 pct heavier products at a cost of 12.4 cents per gallon of total products. Coal hydrogenation products consisting of 16 pct L.P.G., 42 pct gasoline, and 42 pct Diesel oil would cost 12.6 cents per gallon of total products. These figures include all costs, with annual depreciation at 6⅔ pct on the total investment in mines, plants, and pipelines. They do not include a return on the investment, such as interest or profit. Alternatively, coal hydrogenation plants could produce heavy fuel oil for approximately 10 cents per gallon or a high percentage (89 pct) of aviation gasoline and aviation base stock for 15.5 cents per gallon of total liquid products. It is possible that one or the other of these alternatives might be more profitable than the product distribution given above. In these figures, no allowance has been made for byproducts. Separation and sale of chemical byproducts could reduce the net cost of the oil products a few cents per gallon for both the gas synthesis and coal hydrogenation plants. However, as full production of byproducts would flood the market, this credit can be taken only for the first several plants, which may be helped to a considerable extent by the sale of these products. The development of greatly enlarged markets for the chemicals could have a significant effect on the synthetic oil industry as well as on the chemical industry.

Processes

The two principal methods of producing oil from coal are the gas synthesis (Fischer-Tropsch) and hydrogenation (Bergius) processes.

GAS SYNTHESIS

In the gas synthesis or modified Fischer-Tropsch process, the coal first is gasified to produce synthesis gas—a mixture of carbon monoxide and hydrogen. After adjusting the hydrogen to carbon monoxide ratio, the gas is purified and passed over a catalyst

* Cost figures as presented here should not be directly compared with refinery prices of petroleum products, as the latter include return on investment. In the author's opinion an additional 2 cents added to the cost figures given above would provide a liberal margin of profit. If synthetic products were sold at prices equivalent to the cost figures given, the investment would be paid out in 15 years. A margin of 2 cents per gallon would shorten the pay-out time to 10 years.

under suitable conditions of temperature and pressure. The carbon monoxide and hydrogen combine to form chiefly liquid hydrocarbons, with smaller percentages of oxygenated compounds and gases. The products vary over a wide range from solid wax to methane, the relative quantities depending on the catalyst employed, the hydrogen to carbon monoxide ratio, and the conditions of temperature and pressure.

As operated on a commercial scale in Germany with a cobalt catalyst, this process yielded chiefly straight-chain saturated compounds and produced a superior Diesel fuel. The gasoline was not of high quality.

An American improvement in the Fischer-Tropsch process, involving the use of a fluidized catalyst bed and an iron catalyst, is being applied in a commercial plant that now is under construction for converting natural gas to synthetic fuels. This modified process gives a highly olefinic product which can be refined to a high-grade motor fuel. The process does not offer much promise for the direct production of aviation gasoline, but the low-boiling olefins with isomeric low-boiling paraffins from other sources can be used to produce alkylate, an aviation gasoline component.

Byproducts include 5 to 15 pct of oxygenated compounds, mainly alcohols, acids, and ketones, which separate as a water solution. Oil soluble oxygenated compounds also are formed but would normally be converted to hydrocarbons in the refining process.

The operating conditions found suitable for the fluidized process result in a high percentage of gasoline, usually 85 to 90 pct of the total product. The process apparently has little flexibility in this respect. Operations are conducted usually at 600° to 650°F, 250 to 500 psi pressure, with recycle of 3 to 4 volumes of gas per volume of fresh feed, using an iron catalyst.

The Bureau of Mines has carried to the pilot-plant stage an internally cooled converter in which the heat of reaction is removed by flooding a stationary catalyst bed with a cooling oil produced in the process. This process has greater flexibility than the fluidized bed, but the characteristics of the products are similar. It also has the advantage for coal that it can be operated with synthesis gas containing a 1:1 ratio of hydrogen to carbon monoxide and eliminate the oxygen largely as CO_2. With the fluidized bed a high ratio of hydrogen to carbon monoxide, usually 2:1, is used, with elimination of oxygen chiefly as water. Synthesis gas as ordinarily produced from coal would have to be altered by the shift reaction for the fluidized process.

The products expected by these two versions of the gas synthesis process under selected sets of conditions have been estimated as given in Table 1.

Table 1 . . . Products Obtained from Gas Synthesis

	Fluidized Process,[a] Per Cent	Internally Cooled Converter, Per Cent
C_3-C_4	*	10
Gasoline	84	50
Diesel fuel	11	20
Cracking stock		10
Wax		10
Fuel oil	5	
Total	100	100

[a] Processed to gasoline.

The Bureau of Mines program includes extensive research and development work on the gas synthesis process at Bruceton, Pa. Investigations are under way on catalysts, converter design, operating variables, and examination of the products. A demonstration plant to produce 80 bbl of finished products per day by the gas synthesis process is being built by the Bureau at Louisiana, Mo. This plant will incorporate converters developed at Bruceton. Fig 2 is a view of a pilot plant at Bruceton employing an internally cooled converter.

Extensive research and development on the gas synthesis process are also being carried on by most of the leading oil companies and by other industrial firms. Industry at present is devoting considerably greater effort to this process than to coal hydrogenation.

Both the Bureau and industry have developed processes that are decided improvements over German commercial practice.

COAL HYDROGENATION

In this process coal is liquefied directly by reacting it with hydrogen under suitable conditions of temperature and pressure in the presence of a catalyst. The coal is first pulverized and mixed with an approximately equal weight of heavy oil from the process and a small percentage of catalyst. The paste so formed is pumped, with hydrogen, through preheaters into a series of high-pressure vessels. Pressure is maintained at 3000 to 10,000 psi and temperatures controlled at 800° to 900°F. Lighter products of the reaction are separated and further hydrogenated in a vapor-phase operation, while the heavy oils are recycled. The mineral matter (usually about 1.1 times ash plus 0.1 sulphur) and nonliquefied portions of the coal are continuously removed from a portion of the recycle oil. Recycling of the heavy oil and vapor-phase hydrogenation of the light oils permit conversion of all the liquefied coal to gasoline and lighter products, although the process also can be operated to produce chiefly heavy fuel oil or Diesel oil. Some methane and ethane are formed, but they are used to provide part of the hydrogen for the process.

The coal hydrogenation process yields a gasoline of high octane number and good rich-mixture performance that meets military aviation-gasoline requirements. It is noteworthy that the Germans made virtually all of their wartime aviation gasoline by hydrogenation of coal and tar, even though 70 pct of their total oil supply was natural petroleum. Coal hydrogenation offers superior gasoline and high process flexibility. Although petroleum processes generally are considered very flexible, there are definite limitations as to the proportions of products. As a result, with the methods now in use, the output of gasoline cannot be increased greatly without an increase in heavier products. With coal hydrogenation, at least 75 pct of the yield may be confined to one product (gasoline, jet fuel, Diesel oil, or fuel oil), and, if desired, gasoline can be produced without any fuel oil production.

Byproducts of coal hydrogenation include industrially valuable tar acids and tar bases. Based on the moisture- and ash-free coal, tar-acid yields vary from 5 to 15 pct and tar bases from 2 to 4 pct. The tar acid increases with decreasing rank of coal. Other portions of the intermediate products could be used for wood preserving and as solvents. If not separated, these byproducts are converted to hydrocarbons in the process and contribute to the yield of liquid fuels.

The Bureau of Mines is conducting research and development work on coal hydrogenation at Bruceton, Pa., where operating variables and catalysts are investigated in autoclaves and pilot plants and radical improvements in the process are being sought. The Bureau's hydrogenation plant at Louisiana, Mo., (Fig 3) is virtually completed. It will

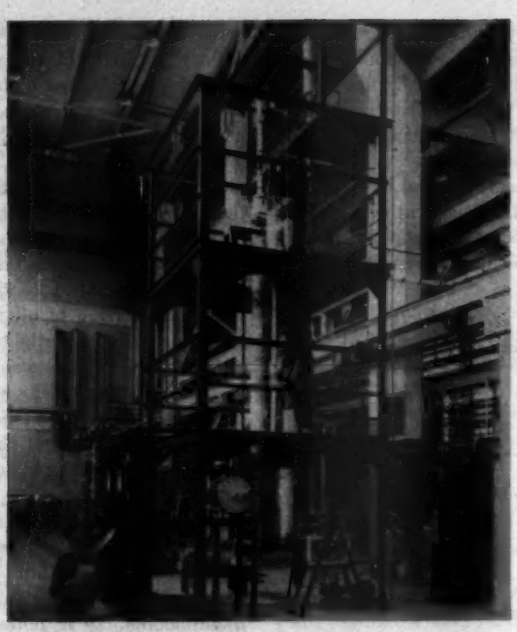

FIG 2—Gas synthesis (Fischer-Tropsch) internally cooled pilot plant. Bureau of Mines synthetic liquid fuels laboratories, Bruceton, Pa.

produce 200 bbl a day of gasoline and can be operated to yield other oil products. This plant has a number of improvements on the best German practice. A small number of prominent industrial firms in this country also are conducting research and development on this process, but the work being done by private industry is minor compared to its gas synthesis studies.

GASIFICATION OF COAL

In the gas synthesis process, the purified synthesis gas accounts for about 70 pct of the cost of the finished product. In the hydrogenation of coal, the cost of compressed hydrogen represents one-third to one-half the total cost of the product. Coal gasification to produce synthesis gas or hydrogen is thus one of the most important problems in converting coals to synthetic liquid fuels. All synthesis gas produced commercially from coal in this country has been obtained by gasifying byproduct coke in standard water-gas machines. There are several objections to continuing this practice for the production of synthetic liquid fuels:

1. Coking coals in enormous quantities would be required for a large synthetic fuel industry, and such relatively scarce coals should be conserved for the manufacture of metallurgical coke and other preferred uses.

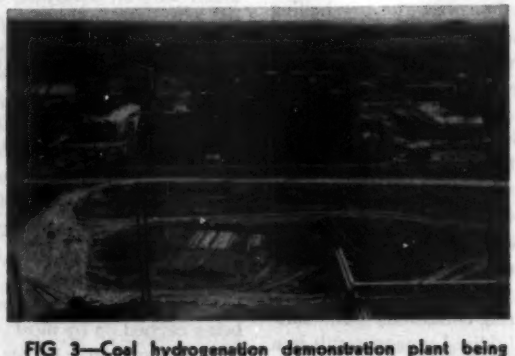

FIG 3—Coal hydrogenation demonstration plant being built by the Bureau of Mines at Louisiana, Mo. Coal is transformed into oil under high pressures and temperatures in the converter stalls (center). Coal preparation unit (upper left) and distillation unit (right).

2. Noncoking coals form a large part of the country's coal reserves.

3. A substantial reduction in costs appears to be possible by directly gasifying coal rather than first coking it and then gasifying the coke.

However, in spite of the numerous estimates, such as those given in this paper, on the production of synthetic liquid fuels in this country, the coal gasification processes on which the estimates are based have not yet been carried out commercially with American coals. Furthermore, the direct coal gasification processes used commercially in Germany required special types of fuel that would severely restrict their application in this country.

The Bureau of Mines is playing a leading part in efforts to develop suitable coal-gasification processes for American synthetic fuel plants. At Morgantown, W. Va., the Bureau has laboratories and pilot plants devoted to the gasification of coal and to the purification of synthesis gas. Other Bureau activities in coal gasification include the externally heated retort, the Lurgi pressure-gasification process, and underground gasification. As the gasification of coal in powdered form is expected to be the process more universally applicable, regardless of coal characteristics, the Bureau is making a threefold attack on this problem.

TYPES OF PROCESSES

The following types of coal-gasification processes are being considered for American synthetic liquid fuel plants:

Gasification of Powdered Coal

At Morgantown, W. Va., the Bureau of Mines has for several months operated a pilot plant[7] gasifying about 20 lb of pulverized coal per hour in oxygen and steam. Although this plant is operated intermittently, its development has reached a stage where it could be operated continuously. The results to date show that gas of synthesis quality can be made by gasifying pulverized bituminous coal.

At Morgantown initial operations have started on a larger pilot plant[8] for gasifying 100 to 1000 lb of pulverized coal per hour in oxygen and steam that has been preheated to the highest possible temperature to minimize the volume of oxygen required. An attempt has been made to design for tempera-

tures as high as 4000°F in the pebble stoves used for preheating steam. Fig 4 is a photograph of the larger Morgantown pilot plant showing, in the foreground, the two Royster pebble stoves for superheating steam.

At Pittsburgh, Pa., the Bureau is investigating the use of the vortex combustor in powdered-coal gasification with steam and oxygen. It has a capacity of 100 lb of coal per hour.

At Louisiana, Mo., a gas synthesis demonstration plant is being constructed for the Bureau of Mines by Koppers Co., Inc. This plant will include a unit for the gasification of powdered coal. The design is based on pilot-plant experiments conducted by the Heinrich Koppers firm in Germany.

FIG 4—General layout of equipment in the pulverized fuel gasification pilot plant of the Bureau of Mines at Morgantown, W. Va.

FIG 5—Linde-Frankl oxygen plant and 50,000 cu ft gas holder under assembly at Bureau of Mines coal hydrogenation demonstration plant near Louisiana, Mo. Brought from Germany, this 23,000 cu ft-per-hour unit will extract oxygen from the air and is the first of its size to be erected in the United States for coal gasification.

To supply oxygen for this gasification unit the Bureau has a ton-an-hour Linde-Frankl oxygen plant that was brought to this country from Germany (Fig 5).

Gasification in a Fluidized Bed

According to published announcements, the direct gasification of coal in a fluidized bed is being investigated by the Pittsburgh Consolidation Coal Co., working in conjunction with the Standard Oil Development Co. The fluidized coal will be gasified by steam and oxygen.

Externally Heated Retort

At Grand Forks, N. Dak., the Bureau of Mines has a pilot plant in which reactive lignite and subbituminous coal are gasified by steam in an annular, externally heated metal retort (Parry process). This process can produce directly a wide range of gases in varying proportions of hydrogen but requires a sized, reactive fuel and therefore does not have the wide application of the powdered-coal process.

Lurgi Pressure Gasification

At Pittsburgh, the Bureau of Mines is experimenting with the Lurgi pressure-gasification process; however, this process requires a reactive, noncoking, sized fuel, and to obtain this material prior processing is necessary with some coals.

Fixed-bed Process

At Battelle Memorial Institute, coal-gasification experiments are being made with a fixed bed under pressure. It is understood that air is being used to make producer gas for other uses, but the substitution of oxygen and steam for air should give synthesis gas.

Underground Gasification

The Bureau of Mines is actively engaged in both pilot-plant and field-scale experiments on underground gasification of coal. Pilot-plant work is being done at Morgantown, and preliminary work for a second field test has been started at Gorgas, Ala., in conjunction with the Alabama Power Co.

Gasification of Anthracite

The Anthracite Institute laboratories are developing processes for the gasification of fine anthracite to produce synthesis gas.

Low-temperature Carbonisation of Coal

Low-temperature carbonization of coal is frequently mentioned as an adjunct to or a substitute for synthetic fuel plants. Low-temperature carbonization is primarily a process to produce a solid, smokeless fuel. Liquid fuels and gas are obtained as byproducts. Low-temperature carbonization of high-volatile coal ordinarily gives the following yields per ton of coal:[3]

Kind of Fuel	Yield
Coke	1,400 to 1,600 lb
Gas (Btu 800–1,000)	3,000 to 5,000 cu ft
Tar	20 to 30 gal
Light oil (for motor fuels)	2.5 to 3.0 gal

The tar produced can be used as a fuel oil or as a raw material for a hydrogenation plant. From the viewpoint of supplying liquid fuels, distillation of the tar beyond the removal of light oil is not very attractive, as 25 to 40 pct is obtained as pitch, while the Diesel oil, produced to the extent of approximately 3 gal per ton of coal, would have a cetane number of only 15 to 20 and would therefore have to be blended with a high-grade Diesel fuel.

There is a possibility of employing

low-temperature carbonization in the large-scale production of synthetic fuels by integrating this process with hydrogenation and Fischer-Tropsch plants. In this case, the tar obtained would go to the hydrogenation plant to be treated along with raw coal, and the low-temperature coke would be used for producing synthesis gas and hydrogen either by the water-gas process or by continuous gasification with oxygen. However, after careful study of various schemes, the Bureau of Mines believes that the direct gasification of powdered coal (without prior low-temperature distillation to obtain the tar) is preferable because of lower investment and operating costs and because of wider application to the different kinds of coal available in this country.

Characteristics of Coal for Synthetic Fuels

Some characteristics of coals will have a bearing on their use for either the gas synthesis or hydrogenation process. These include ash content, moisture content, storage properties, and, especially, uniformity.

Although high-ash coal can be gasified, it is axiomatic that low ash is advantageous in almost any process using coal and that the value of ash reduction increases with the cost of such processing. Therefore, as gasification for either the gas synthesis or coal hydrogenation process and primary liquefaction in the latter process are expensive, it appears likely that coal washing will be justified.

High surface moisture can cause handling difficulties with fine coal. In any case, the moisture in the coal, if not removed by prior drying, requires heat for evaporation in the processing and therefore may, and very likely will, be a disadvantage.

As synthetic oil plants operate continuously, some coal must ordinarily be stored at the plant to provide for operation when mines or transportation facilities are idle. Coals that weather rapidly will require special facilities for storage.

Uniformity is one characteristic of coal that will doubtless be extremely important for both the gas synthesis and hydrogenation processes. Gasification of coal with oxygen and steam to produce synthesis gas or hydrogen is likely to be a delicately balanced operation that will require a constant feed of uniform-quality fuel. Coal for liquefaction in the hydrogenation process must also be uniform, as variations in ash or petrographic constituents could affect the catalyst requirements and operating conditions.

Cleaning and dewatering, or drying, are thus indicated for synthetic fuel plant coal to ensure reduced ash, controlled moisture, and uniformity. Coal cleaning will also permit mechanical mining, which usually results in excessive impurities in the raw coal.

Table 2 . . . Effect of Sulphur Content of Coal on Synthesis Gas Purification Costs

Based on a Plant Producing 10,000 bbl of Oil per Day and 26 lb of Coal per M cu ft of Raw Synthesis Gas

Per cent sulphur in coal	1 pct	3 pct	5 pct
Investment in purification equipment	$3,865,000	$5,447,000	$6,688,000
Recoverable sulphur per day, tons	38	118	198
Total cost of sulphur removal per ton of coal gasified	$0.75	$1.15	$1.52
Net Cost of Purification per Short Ton of Coal Gasified Based on Various Sulphur Credits:[a]			
Credit per long ton sulphur recovered			
$ 5	$0.71	$1.03	$1.32
$10	0.67	0.91	1.12
$15	0.62	0.79	0.91
$20	0.58	0.67	0.71
$25	0.55	0.55	0.51

[a] Sulphur credits include credit for heat recovered from sulphur conversion process, if any.

GAS SYNTHESIS PROCESS

Characteristics of coal that may affect particularly the gas synthesis process are the sulphur content, ash-softening temperature, and coking properties. Rank of coal is not important; any rank from anthracite to lignite can be used.

As the synthesis gas must be virtually free from sulphur compounds, high-sulphur coal will increase the cost of gas purification. Table 2 summarizes recent estimates on the cost of synthesis gas purification. These figures indicate that, where a liberal credit can be obtained for sulphur recovered, high-sulphur coals may be acceptable. If little or no credit is available from the sale of sulphur, reduced purification costs alone might in some instances justify cleaning the coal.

Coal gasification must be carried on at temperatures of at least 1800°F, and it may be desirable to employ considerably higher temperatures to eliminate tar and gum-forming constituents from the gas. With either nonslagging or slagging processes, the ash-fusion temperature is likely to be an important factor. It must be high enough so that the ash will not fuse in the nonslagging process and low enough to fuse completely in the slagging process.

If coal is to be gasified in the fluidized state, as has been proposed, the coking characteristics of the coal may be very important. With strongly coking coal, it may be necessary to recirculate large quantities of noncoking material to prevent agglomeration in the fluidized bed. For the production of synthesis gas by the Parry process, a very reactive noncoking fuel is required, such as lignite or subbituminous coal. Use of the conventional water-gas process would require noncoking fuel, such as anthracite or coke.

Approximately one-eighth of the total coal for a gas synthesis plant is used to produce steam and power. This presents no problem; and, especially in the case of a captive coal mine, it might be a decided advantage as the boiler plant could be designed to handle portions of the coal less desirable for gasification, such as middlings from a cleaning plant, fines that cannot be economically cleaned, or carry-over from the gasification units. If coal is purchased, the most economical steam coal can be used for boiler fuel.

COAL HYDROGENATION PROCESS

The matter of coal selection, or coal distribution in the case of a single source of coal, is much more complicated for a coal hydrogenation plant than for a gas synthesis plant. A commercial plant using the hydrocarbon gases formed in the process as a source of hydrogen would have four different uses for coal, divided approximately as follows:

	Per Cent
Process coal for liquefaction	53
Gasification coal for hydrogen	12
Coal for producer gas	9
Coal for steam and power	26
Total	100

The process coal for liquefaction is, of course, the critical portion. The other uses may in some instances be advantageous, as the equipment may be selected to utilize cheaper coals, or portions of the coal from a captive mine that are less desirable for liquefaction.

Table 3 . . . Fuel and Water Requirements for 10,000 Barrel-per-day Plant

	Hydrogenation	Gas Synthesis
Bituminous coal (11,900 Btu per lb)		
Tons per calendar day	4,300	5,100
Tons per year	1,576,000	1,849,000
For 20-yr life of plant	31,300,000	36,700,000
Daily mine capacity required (at 260 days per year)	6,000	7,100
Subbituminous coal (9,500 Btu per lb)		
Tons per calendar day	5,200	6,400
Tons per year	1,900,000	2,300,000
For 20-yr life of plant	38,000,000	46,000,000
Daily mine capacity required (at 260 days per year)	7,300	9,000
Lignite (7,500 Btu per lb)		
Tons per calendar day	6,600	8,100
Tons per year	2,400,000	2,900,000
For 20-yr life of plant	48,200,000	58,300,000
Daily mine capacity required (at 260 days per year)	9,200	11,300
Anthracite (13,500 Btu per lb)		
Tons per calendar day		4,500
Tons per year		1,619,000
For 20-yr life of plant		32,380,000
Daily mine capacity required (at 260 days per year)		6,300
Water—Minimum stream flow available (spray cooling and recirculation)		
Intake, million gallons per day	9.6	12.1
Net consumption, million gallons per day	6.6	8.1
Water—Unlimited stream flow available (no recirculation)		
Intake, million gallons per day	167.	167.
Net consumption, million gallons per day	0.8	1.

Coal for Liquefaction

Common, banded, bright coals ranging in rank from high-volatile bituminous to lignite are generally suitable for liquefaction by coal hydrogenation. The higher rank medium and low-volatile coals are liquefied to a lesser extent and therefore yield less oil per ton of moisture- and ash-free coal. Anthracite yields virtually no liquid hydrocarbons under hydrogenation conditions.

In addition to the rank of the coal, the petrographic constituents must be considered. Anthraxylon or vitrain in high-volatile and lower-rank coals is almost completely (95 to 98 pct) liquefied. Splint coals give comparatively low liquefaction yields—60 to 87 pct in those tested. Fusain is the least reactive constituent and gives very low yields. Some cannel and boghead coals that are low in fusain and opaque attritus may be suitable.[10]

In general, splint coals should be avoided. Fusain usually can be eliminated to a considerable extent by dedusting or cleaning the coal.

Usually, the lower-rank coals are more readily and more completely liquefied than the higher-rank coals. This tends to offset the disadvantage of high moisture characteristic of the low-rank coals. The yields for various suitable coals in this process are roughly proportional to the heating values of the coal as received. The yields of tar acids are appreciably greater with lower-rank coals.

Mineral matter in coal for hydrogenation may have other disadvantages in addition to its direct detrimental effect in displacing coal in the processing. In the German process, elimination of the mineral matter from the system involved removal of about an equal weight of oil, much of which eventually was lost. Therefore, high mineral matter was more detrimental than would normally be expected. However, processes are being developed which, it is hoped, will result in removal of the mineral matter in a dry material, thus avoiding loss of oil. Sulphur content and ash-fusion temperature are of little consequence in the coal hydrogenation process.

The composition of the mineral matter in coal for hydrogenation may be a factor. Some mineral matter may act as a negative catalyst and require chemicals to neutralize the effect. A high calcium content may contribute to the formation of deposits in the converters. Acidity and chlorine content of the coal affect the quantities and types of chemicals added. Actual tests are usually needed to measure the extent of these influences, which usually are not serious.

Coal for Gasification

The requirements for gasification coal to produce hydrogen are the same as for the production of synthesis gas, except that sulphur content is of less importance, as gas purification is optional and, when used, would not have to be carried to the low concentration of sulphur compounds required for the gas synthesis process.

Coal for Producer Gas

Fuel gas for heating purposes in the plant can be made in conventional air-blown gas producers if suitable fuel is available. Gas producers operate best on a sized fuel with fairly high ash-softening temperature. Low-rank, noncoking coals that decrepitate to fines on heating might not be suitable fuels. If no suitable fuel is available, special gasification equipment might be required, or one of the synthesis gas generators might be operated with air instead of oxygen to produce cheap fuel gas.

Coal for Steam and Power

Boiler house equipment would be selected, as in the gas synthesis process, to burn coal less desirable for other uses—middlings from the cleaning plant or fines—or, in the case of purchased coals, the most economical steam coal available.

Nation-wide Survey for Synthetic Fuel Plant Locations

At the request of the Secretary of the Interior, the Corps of Engineers of the Department of the Army is making a survey for the Bureau of Mines to determine suitable areas in the United States and Alaska for the location of synthetic liquid fuels plants. A contract already has been let for the first part of this work covering the following areas: northwestern Colorado, western Kentucky, and a part of southeastern Texas.

Economic and Geographical Factors

Some of the factors to be considered in attempting to predict which coals will be preferred for large-scale production of synthetic liquid fuels include:

1. A plant producing some 10,000 bbl of oil per day will require the quantities of coal and water shown in Table 3, both of which must be assured for the entire life of the plant. For larger plants the requirements would be roughly proportional to the output. Numerous locations in the United States have ample coal reserves for commercial synthetic fuel plants, but in the western states that have the largest coal reserves, water supplies may restrict the number and size of plants.

2. As a wide range of coals can be used, preference doubtless would be

given those with a low cost per million Btu delivered to the plant. This would tend to eliminate coals that command higher prices, such as the metallurgical coking coals, the prepared sizes of anthracite, and coals with high mining costs. It would also favor coals close to suitable plant sites.

3. Where new mines must be opened, strip mining offers such advantages over most deep mines as fewer men to train and house and more rapid development to full production.

4. For the gas synthesis process, lower-rank coals and lignites at the same cost per million Btu would be less desirable than higher-rank coals. Because moisture increases the cost of handling and drying, low-rank, high-moisture fuels must be made available at a lower cost per million Btu. However, in the case of coal hydrogenation, compensating factors partly, if not completely, offset the disadvantages of low-rank coals. These coals are more reactive and generally liquefy more completely than high-rank coals. Consequently, conversion costs are lowered enough to offset increased handling and drying costs. This factor improves the competitive position of hydrogenation for the lower-rank fuels.

5. Proximity to markets and transportation facilities undoubtedly will be factors.

6. Availability of suitable labor would be important. While housing might have to be provided in almost any geographical area, regions remote from centers of population would require the importation of workers and the establishment of complete towns with churches and schools in addition to houses.

7. Variations in climate through the coal fields of the United States are not great enough to affect plant operations seriously. Alaska, on the other hand, doubtless would present some difficulties due to the long, extremely cold winters.

8. The capital investment for plants in the western states, such as Wyoming, North Dakota, Colorado, and Montana, which have the greatest coal reserves in the United States, would be higher than for plants in some eastern locations. The distance from steel and equipment manufacturing centers and the need for long pipelines to the major markets increase construction costs. The occurrence in the west of thick coal seams that can be strip mined at low cost with reduced manpower is a compensating factor that might more than offset the higher initial plant and pipeline cost.

9. National defense considerations might oppose the concentration of great plant capacity in one area or erection of a plant close to an important target.

10. The first plants constructed are likely to be integrated with other operations such as the chemical or gas industries. This would favor the use of coals that are reasonably close to large chemical and natural gas markets.

11. The existence of available facilities, such as developed mining capacity or a coke plant of sufficient size to provide coke and coke-oven gas for the production of hydrogen or synthesis gas, might readily influence the location of the initial plants.

Concluding Statement

More important than the question as to which coal will be used for the initial synthetic fuel plants is the question of when they will be built. The need for prompt erection of at least a few commercial plants was aptly brought out by R. A. Cattell, chief of the Petroleum and Natural Gas Branch, Bureau of Mines, in a recent letter,[11] part of which is quoted here:

Synthetic liquid fuels are not going to do us very much good in an emergency if we have to start from scratch, or from an unduly small nucleus. I often think of our experience in helium production. In World War I helium production was started from scratch, and only 200,000 cubic feet had been produced when the Armistice was declared. When World War II started, we had one plant and the output was small, but we had a well-trained staff and crew of men, and the wheels were turning. We were able to expand from that one plant to five plants, and increase the production 22 fold. The needs for helium were met as fast as they developed. During World War II our production in 12 hours exceeded the 200,000 cubic feet that was produced during all of World War I.

Acknowledgments

Grateful acknowledgment is made to A. C. Fieldner and W. C. Schroeder, under whose direction the paper was prepared; to R. A. Cattell, H. H. Storch, L. D. Schmidt, J. A. Markovits, W. H. Lyon, and H. C. Stewart, who reviewed the manuscript and made helpful suggestions; and to H. R. Batchelder, H. A. Ingols, and A. E. Sands, who prepared estimates of gas purification costs.

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XUM

First Meeting of Extractive Metallurgy Division On Zinc and Cadmium

REPORTED BY T. D. JONES, W. S. REID, H. R. HANLEY, AND JOHN SULLIVAN

Although the published subject had been lead and zinc, the first session of the newly organized Extractive Metallurgy Division could well be termed an all zinc-cadmium meeting. Carleton Long called the 65 members present to order to hear two papers on new developments in the electrolytic zinc plant and recovery of cadmium at the Risdon works in Tasmania, by L. P. Davidson and Walter Woolf.

"Cap" Hanley had a field day discussing trees, rotating cathodes, and thallium removal. Cadmium recovery at Donora, Pa., and at the Bunker Hill refinery was presented by M. M. Neale and Harold Lee, while an international flavor was added by Gordon, of the Risdon works, and Morgan, of the Imperial Smelting Works, Avonmouth, England.

On Tuesday morning Art Collins lead off the all-smelter session on the effect of high copper content on a blast-furnace charge and subsequent drossing of the lead bullion. T. H. Weldon came across with a paper on oxygen enrichment in the metallurgical operations at the Trail plant. W. S. Reid's paper on concentration of SO_2 content of the D-L sintering machine gas by recirculation created keen interest. E. P. Fleming, at the Selby plant, has pioneered recirculation of D&L gases, used for production of sulphuric acid. H. K. Najarian brought to light the intricate mechanics of the Risdon roaster; hereafter, pitch of teeth, slope, and rpm of roaster arms will have fuller meaning to those who heard the author explain a difficult treatise on multiple-hearth roasters.

A round table discussion on blast furnace charge preparation and dross treatment occupied the Wednesday morning session. Conceived, organized, and executed by Ronnie McNaughton, a feature of the meeting was that the "brains" of the lead smelting industry were all present under one roof. Collins and Fleming discussed sinter feed preparation and representatives of the large smelting units really let their hair down, to be needled by Ronnie if they hesitated.

The Wednesday afternoon session was devoted to retorts and equipment with H. R. Page and A. E. Lee, Jr., on the development of the modern zinc retort, stressing the integrity of this refractory receptacle as a leading characteristic in the distillation of zinc. The silicon-carbide retort succeeds the one of refractory clay component and though costly, has proved economical in practice with many types of charge and with a knowledge of operating characteristics.

Arthur D. Terrell reviewed the history of the art of zinc distillation, initiating the discussions. Ken Morgan commented on the different European, English, and American clays, the latter being more plastic than the other two. C. R. Kuzell asked about retort porosity and absorption of zinc vapors to retort walls.

Stress was given in the second paper, prepared by R. R. Furlong and Donald Wertz, but presented by M. M. Neale, to rapid drying through automatic control of humidity by valves, reducing drying time from 45 to 4 days, with no failures due to the speed. Gunnard Johnson dealt with the development of muffle furnaces for the production of zinc oxide and zinc, this having been the first formal paper on such units used to treat worn out die castings and similar alloys. The last paper on the session described the slag treatment plant at the El Paso smelting works, authored by T. J. Woodside.

The session on titanium was devoted to processing ilmenite and titaniferous ores to produce intermediate products that might be used in the production of titanium pigments or titanium metal. The four formal papers were contributed by the National Lead Company's Titanium Division, the last prepared jointly with the Bureau of Mines, to form a symposium, ending with a discussion that proved lively indeed.

The Thursday afternoon session was concerned with aluminum, copper, and zinc, starting with an abstract by J. D. Sullivan on reflections on the electrolytic cells used in the production of aluminum. An excellent description of the Morenci smelter was given by L. L. McDaniel. Being the most modern copper smelter in the country, practices there are of great interest to all copper producers.

The paper on continuous casting, by Smart and Smith, described the plant and procedures for the production of continuously cast copper and copper-base alloys. F. F. Poland presented his paper "Distillation of Zinc from Copper-base Alloys and Galvanizers' Drosses," describing a unique type of electric furnace for the distillation of zinc. High recoveries of zinc can be obtained, with appreciable savings in cost.

Coal Division Presents Excellent Papers and Discusses Divisional Reorganization

REPORTED BY DAVID R. MITCHELL

Outstanding at the San Francisco meeting was the excellence of the papers and discussions at the six technical sessions. Emphasizing western coals, this meeting will long be remembered for the useful operating ideas and basic engineering information presented which were applicable not only to western conditions but to other areas and conditions of operation. Much of the information presented is directly usable by the American coal mining industry; much was basic, pointing the way to the solution of many problems facing the industry.

Of the nineteen papers presented, nine were on preparation; four on economics and utilization; four on underground mining; and two on strip mining. New techniques in cleaning and dewatering the extreme fine sizes were given in several of the preparation papers, while new mining techniques received attention in the underground and strip mining papers. The over-all strategic importance of West Coast coals was stressed in several papers.

Activities for the coal group started Sunday afternoon with the Education Division meeting at Berkeley. Several coal men were present and the paper by Charley Lawall on "Mineral Engineering Education in Light of Present Day Developments" was well received.

At the annual luncheon meeting of the Coal Division, Clayton G. Ball, retiring Chairman, introduced the new Chairman, E. R. Price, who spoke briefly of the plans for reorganizing the Coal Division and the objectives of the various working committees. At this meeting, changes in the By-laws were approved to make it possible to put into effect the recommendations of the Wright Committee for the reorganization.

This reorganization replaces the many former technical committees by three: *Mining*, under the Chairmanship of Jerry Woomer, consulting engineering, Wheeling, W. Va.; *Preparation*, R. E. Zimmerman, head, division of mineral preparation, State College, Pa.; and *Utilization*, C. A. Reed, director of engineering, National Coal Association, Washington, D. C. Subcommittees have been organized to study and report on specific problems.

About seventy-five members were present at the luncheon meeting. This compares rather favorably with the attendance at Eastern meetings, considering the distance from the nation's principal coal mining areas.

The Executive Committee meeting approved a report from the Special Committee studying the Johnson report on reorganization of the Institute. Among other things, this report recommended "that the Johnson report be kept alive, and that a special committee of the Board of Directors of the Institute report to the Board at least twice a year on the continued application of the principles in the Johnson report for the best interests of the Institute's membership, and furthermore, that the Board use vigilant efforts to increase the Institute's income from advertising and all other sources of income."

A recommendation to have the next joint meeting at French Lick Springs, Ind., on Oct. 26 and 27, 1949, was approved. Chairman Price appointed Richard H. Swallow, chief engineer, Ayrshire Collieries Corp., Indianapolis, general chairman for this meeting. Mark this date on your calendar since the preliminary plans indicate the Coal Division will have an exceptionally good meeting at French Lick Springs.

The Division has also agreed to participate in the Regional Meeting of the Institute at Columbus, Ohio, during the week beginning Sept. 26. A two day technical program is being arranged by Elmer Kaiser, Coal Division Program Chairman, for the Columbus meeting.

The Coal Division is honored by having one of its members, L. E. Young, selected as President of the Institute for this year.

Another item of general interest to Coal Division members, and not as yet widely publicized, is the establishment of the Erskine Ramsey gold medal for meritorious achievement in coal mining. The first of these medals was presented to Eugene McAuliffe at the San Francisco meeting. Coal Division members are grateful for the establishment of this award for several reasons: (1) an outstanding member of the coal mining industry can now be honored at the same top level of the four other gold medals awarded by the Institute; (2) it carries the name of Erskine Ramsey, long recognized for his achievements in the coal industry; and (3) it was particularly pleasing to have the first award presented to Eugene McAuliffe.

Despite the attractions of Chinatown, The International Settlement, Fisherman's Wharf, Seal Rocks, and the many other fascinating spots in the San Francisco Bay area, attendance at technical sessions was good, ranging from 50 to 100 per session. Those members and their wives who braved the vicissitudes of travel to attend will long remember this anniversary meeting on the West Coast in honor of the 49'ers.

Government's Role in a National Mineral Policy

(*Continued from p. 19*)

way. That can be left to industry. The co-operative work done during the war set a good pattern that might well be followed, with reasonable restraint, even in peacetime.

Under special circumstances, drainage projects, either long adits or pumping installations, might be proper for the Bureau of Mines to undertake in districts where the development of ground with good prospects for ore was prevented by excessive water. Each venture of this sort should stand on its own merits, and decisions should be reached only after careful appraisal of magnitude of returns and cost, distribution of ownership, means of repayment from those who are benefited, methods of handling the work, and the lack of interest on the part of private groups.

To sum up, I am of the opinion that the two best services the mining industry could receive from the government today would be tax relief and economy in expenditures. The Geological Survey and Bureau of Mines are not, however, to be regarded as agencies that have been extravagantly handled. On the contrary, they have received and deserved the commendation and the support of the great industries they serve as well as the interests of the whole people. Economies in specific activities should be made with care, for unwise curtailment of essential functions could easily lead to losses of much greater magnitude in operations undertaken with inadequate data.

Reasonable expansion of their services seems desirable and needed to meet their full responsibilities under national policies such as I have outlined. Research directed primarily toward broad objectives surely should continue to receive strong support. Preoccupation with special assignments of apparent immediate practical character should not be allowed to divert their major talents from work of general and basic character. Important specific jobs must, of course, be undertaken in relation to current or long-range needs, but in each their objective, except under exceptional circumstances, should be simply to demonstrate facts and what can be done from exploration to pilot-plant stage, with actual operation of mines and plants on a commercial scale left to private enterprise after the opportunity is adequately revealed.

Book Reviews

Prospecting for Uranium

"Handbook of Uranium Minerals" is just another name for a bound set of rules on how and where to find uranium. Apparently that atomic-age sport of hunting for radioactive minerals is fast gaining popularity, for the original 1947 printing of the "Handbook" was quickly exhausted. And now the authors, Jack DeMent and H. C. Dake, have prepared a revised and enlarged edition, to sell at $2 a copy. So nominal a purchase, if made, might be a sound investment, especially in view of the fact that the U. S. Atomic Energy Commission is offering awards up to $10,000 for the discovery of new uranium ore deposits. The transaction can be negotiated through the Mineralogist Publishing Co., 329 S. E. 32 Ave., Portland 15, Oreg.

Limestone Porosity

Some light has been thrown on the petroleum geologists' problem of "The Nature and Origin of Limestone Porosity," by Richard B. Hohlt in a paper dubbed with that ancient problem. Therein he tries to analyze the existing concepts of the nature and origin of carbonate porosity, and to present evidence for the modification or expansion of some of these concepts. The outcome of his endeavors is available for $1, from the Dept. of Publications, Colorado School of Mines, Golden.

Mexican Mining Taxes

"Mining Taxes in Mexico" is the subject of a special supplement, No. 25, to the April 1948 issue of *Mineral Trade Notes*, the Bureau of Mines' monthly inventory of exclusive mineral information. The collection comes into print because of J. K. Burnham's consideration for those interested readers who find difficulty in comprehending the operation of foreign tax laws. Mr. Burnham explains the Mexican mining industry's burden in nontechnical language, thus eliminating the necessity to consult the usually inaccessible sources that help translate barristers' terminology. Further thoughtfulness on the author's part is evidenced by his explanation of calculating taxes at any given time, in order to take care of the fluctuating peso exchange rates and New York mineral market quotations.

Industrial Health Practices

A factual study which shows the trend of industrial health administrative practices, covering over a million people included in 278 groups in 33 states, and constituting a "fair statistical sample" of what is going on in industrial health departments, has been issued by the Industrial Health Foundation. Detailed presentation and analysis of such things as personnel, departmental set-ups, and costs, are presented in this study, which was begun in 1945, to modernize a bulletin issued thirty years ago. "Industrial Health Department Functions and Relationships" is available from the Foundation, 4400 Fifth Avenue, Pittsburgh.

Safety Posters

A handy 72 page directory of occupational safety posters, containing 744 illustrations in two, three and four colors, provides an easy way to locate posters covering accident hazards in fifteen types of work. Everything from hoists to horseplay, from Christmas to dermatitis, and the dangers attached thereto, is graphically presented now in poster form. The 1949 Directory of Occupational Safety Posters is available from the National Safety Council, 20 N. Wacker Drive, Chicago 6, Ill.

Canadian Geology

Structural Geology of Canadian Ore Deposits. A symposium arranged by a Committee of the Geology Division of the Canadian Institute of Mining and Metallurgy. 1948. 948 pp.

REVIEWED BY PHILIP J. SHENON

Commemorating the 50th anniversary of the founding of the Canadian Institute of Mining and Metallurgy, this book is a major contribution to the literature on mining geology in North America. Compiled under the direction of M. E. Wilson, it represents the combined efforts of 121 leading Canadian geologists and engineers. The purpose of the volume, as stated in the preface, is to assemble up-to-date information on the structural features that have controlled the deposition of ore in the Canadian metalliferous mines. However, it is clearly evident that the stated purpose is far exceeded, for the description of each district includes a reasonably complete summary of all phases of the geology as well as information on history and production.

The papers comprising the text are grouped geographically into three divisions: (1) the Cordilleran region, including most of British Columbia and the Yukon and parts of Alberta and the Northwest Territories; (2) the Canadian Pre-Cambrian shield, comprising most of the east half of Eastern Canada lying to the west of the St. Lawrence River; and (3) the Appalachian region, which includes Nova Scotia, New Brunswick, and Prince Edward Islands. The opening chapter of the book contains papers that describe in broad terms the physiographic features, geologic setting, structures, and general features of the ore deposits in each of the three regions. For descriptive purposes the mines of the Cordilleran region are placed into three groups — Coastal Belt, Interior Belt, and Rocky Mountain Belt. Twenty-eight mines are described under these three headings. Except for Hedley Mascot, Nickel Plate, and Sheep Creek, which are omitted, the mines of the Cordilleran region are well covered. The Pre-Cambrian shield region is subdivided according to mining districts or camps, and 81 mines are described following papers on the general structural relationships for each district. The Appalachian region is divided into two groups, Eastern Township and Gaspe, and Nova Scotia. Three papers describe the mines of the first group and two papers those of the second group. The index is complete and well arranged and all papers are liberally illustrated with plan maps, sections, and photographs. The colored photographs illustrating the paper on the Relationships of Minor Structures to Gold Deposits are beautifully done, as are the black and white photographs illustrating underground structures.

It is impossible to comment on all the many deserving papers that constitute this fine new volume. However, it is worth while emphasizing that most of the material is refreshingly new and that it adds much to the science of ore finding. For the classroom, or for the exploration geologist and examining engineer, this book should prove to be extremely valuable and it is hoped that this splendid work may inspire the production of similar volumes in other countries. In the words of Dr. Charles Camsell, past president of the Canadian Institute of Mining and Metallurgical Engineers, "the volume represents a great piece of team work among authors—." To this all readers will heartily subscribe.

Mining Revived in Historic Area

A new bulletin entitled "A Contribution to the Published Information on the Geology and Ore Deposits of Goldfield, Nevada" by Fred Searls, Jr., noted mining geologist and president of the Newmont Mining Corp., was published recently by the Nevada State Bureau of Mines, Reno.

Mr. Searls, as geologist for the Goldfield Consolidated Mining Co. in the days of great production, gained an intimate knowledge of the geology of the district and also appraised the varying theories of ore deposition, none of which gave any hope to the extension of the ore bodies out beneath the Siebert Lake bed formation to the southwest. Over thirty years later Mr. Searls recommended the expenditure of capital to test out his geological hypothesis to the contrary. In this bulletin he describes this hypothesis, the recent steps taken to prove it, and the successful results obtained to date. How large and profitable this new ore body may prove to be is still conjectural, however, its discovery has opened up the possibility that similar ore may exist alongside the Columbia Mountain fault extending, as traced by geophysical means, out beneath the overlying barren formations for a considerable distance to the southwest of the old bonanza area.

With the bulletin is a geological map of the Goldfield district, valuable not only in order to supplement Mr. Searls's lucid description, but also because the original geological map issued by the USGS has long been out of print, and this new map includes, in addition, the geological mapping carried out under Mr. Searls's direction of the now-promising adjacent area to the southwest.

Jay A. Carpenter, director, states that the Nevada State Bureau of Mines will distribute this bulletin gratis to Nevadans making application for University of Nevada Bulletin Vol. 22, No. 5; to others fifty cents.

Mining in Missouri

A bulletin issued by the University of Missouri's School of Mines and Metallurgy provides a compact review of the State's mining and mineral resources, including a bit of history, and a mineral-by-mineral breakdown. No. 73 is the School's Technical Series; the fifty page bulletin will later be incorporated as a chapter in the "Resources of Missouri" Volume, which is now in preparation, and will be issued at a later date by the University of Missouri.

The St. Lawrence Area

Bulletin 23 of the Newfoundland Geological Survey is a study of the general geology and mineral deposits of the St. Lawrence area, Burin Peninsula, in Southern Newfoundland. Special emphasis is placed on fluorspar, as two mining companies are now working fluorspar deposits in that area. Bulletin 24 is concerned with the geology of southern White Bay, designed to aid development of mineral resources there, where many unsuccessful efforts to bring a gold mine into existence have been made. Both bulletins are available from the Geological Survey of Newfoundland, Government Building, St. Johns.

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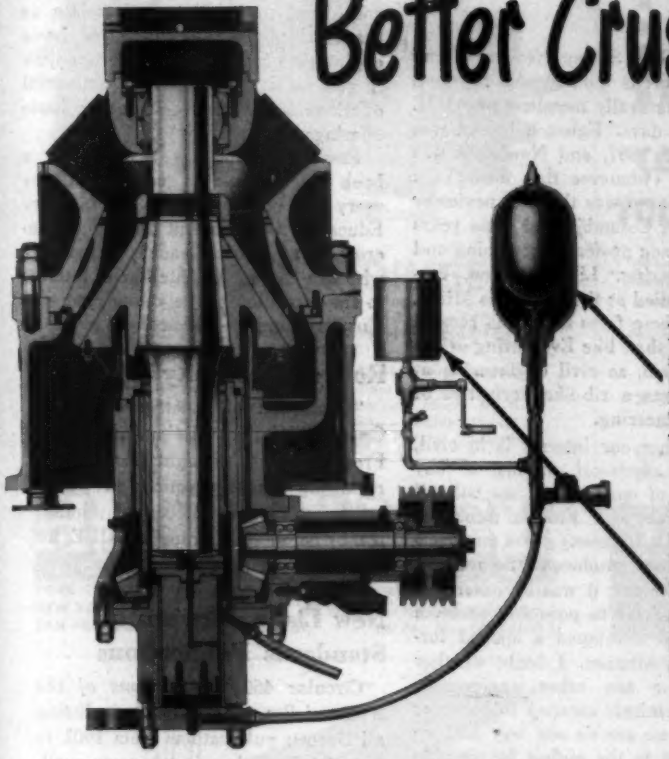

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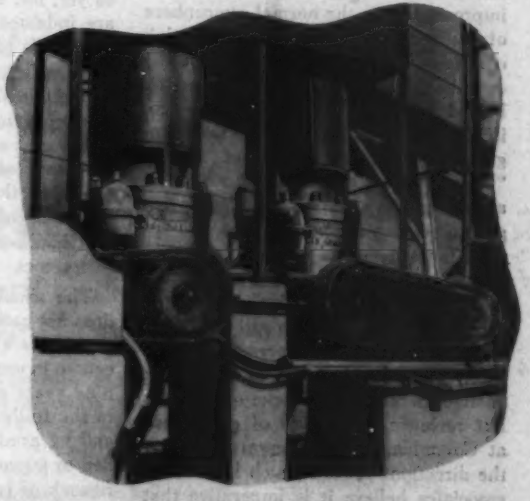

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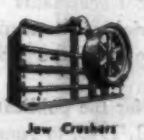
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Book Reviews (continued)

Engineering Education

Trends in Engineering Education—The Columbia Experience. By James Kipp Finch. Columbia University Press. 1948. 140 p. $2.

REVIEWED BY FRANCIS A. THOMSON

UNLESS from the great mass of humanity, democracy can find, recognize, and elevate those relatively few human beings of special gifts in whose hands progress rests, all educational activities are but wasted effort.

These are the closing words of Dean Finch's highly significant and exceedingly well-written little book. I suspect that such a statement will find vastly more general acceptance among members of the Institute than in a gathering of men and women of the so-called "progressive educational" school of thought, among whom it seems to me *educability* of the student is almost totally ignored.

Lest Dean Finch's attitude be regarded as ultraconservative, let me jump from the conclusion to the preface. In this he remarks "change, continual and never-ending change and improvement, is the normal atmosphere of engineering life and of engineering education." This is reminiscent of the quotation from C. F. Kettering, which I used over and over three years ago, in the course of our reconversion program at Montana School of Mines: "When you are satisfied with what you are doing, the concrete has already begun to set in your head."

Thus we have two eminent engineers, one from academic life, the other from industrial life, saying the same thing, each in a manner appropriate to his own experience and temperament. However, the author is not advocating change merely for the sake of change; but reviewing his years of experience at Columbia, he sets forward some of the directions toward which he and his associates believe it is imperative that engineering education must progress.

Since he is a civil engineer, Finch's discussion naturally and properly tends in the direction of his own field, yet virtually all of his conclusions are equally applicable to education for the mineral industry. It is interesting and proper, too, that the book should be dedicated to the first members of the faculty of Columbia School of Mines: Thomas Egleston, Charles Frederick Chandler, John Strong Newberry, and Francis Laurens Vinton. All of these men were naturally members of AIME in its early days. Egleston indeed was president in 1887, and Newberry was "manager" (whatever that meant) in 1876-78. Vinton was the first professor of mining at Columbia and some years later was made professor of mining and civil engineering. Like Egleston, Vinton had studied at the École des Mines. I mention these facts merely to remind Dean Finch that, like Eve having origin in Adam's rib, so civil engineering at Columbia was a rib-like derivative of mining engineering.

But whether our interest is in civil, mechanical, electrical, mining, or any other form of engineering, we will all heartily agree with Finch's trenchant statement that for many years engineering instruction produced "formula hunters", who felt it was unreasonable for the instructor to pose any problem until he had developed a special formula for its solution. I doubt whether Columbia or any other engineering school has entirely escaped this danger as yet, but we are on our way and we are indebted to the author for emphasizing this pitfall.

Nevertheless, however much engineering instructors may have sinned in endeavoring to train "formula hunters", the success of the author himself and of thousands of other able engineers demonstrates that their students escaped from this and other mental handicaps that had been placed on them by their instructors.

The usual length of reviews in ME does not permit more than passing mention of the abandonment of the six-year course in engineering at Columbia after nine years of trial, followed by return to the traditional four-year curriculum, and by graduate work for those qualified to pursue its regimen. (I recall the remark of one Columbia graduate during the trial of the six-year curriculum that there were almost as many students in mining at Columbia as there were members of the faculty.)

Dean Finch's emphasis on the indispensability of the "humanistic core"—English, literature, history, and economics—is now, I trust, accepted by every mining school in the country. This, I think, is also true of the author's sane observation:

"The urge to add new subjects is still with us, but we have reached the point where the general education courses (English, history, and economics) are considered to be just as inviolate as the mathematical, scientific, or basic engineering subjects. In short, adjust if you must the special departmental offerings but do not disturb the basic offerings."

Finally, let me say that this is a book which should be read not only by every member of the Mineral Industry Education Division, but also by the increasing number of leaders in industry who are taking an intelligent interest in the education of the young men who must ere long be taking their places.

Role of Electricity in Mining

"Utilization of Electric Power in Open Pit Copper Mining," by S. F. French and H. Speight, is a paper reviewing recent practices in power utilization in open-pit copper mining. It may be obtained from the AIEE, 29 West 39 St., N.Y.C., for 60¢.

New List of Bureau of Standards Publications

Circular 460, *Publications of the National Bureau of Standards*, listing all Bureau publications from 1901 to June 30, 1947, has just become available from the Superintendent of Documents for 75¢ (375 p.).

The National Bureau of Standards is the principal agency of the Federal Government for fundamental research in physics, mathematics, chemistry, and engineering. Its activities include research in electricity, electronics, atomic physics, applied mathematics, mechanics and sound, radio and radio propagation, optics, heat and power, metallurgy, metrology, ordnance, physical chemistry, mineral products, organic and fibrous materials, and building technology. The Bureau also has custody of the national standards of physical measurement and conducts research leading to the improvement of these standards and techniques of measurement. Improved methods of testing materials and equipment are developed, physical constants and properties of materials are determined, and technical processes are investigated.

Brief abstracts for the publications issued from Jan. 1, 1942, to June 30, 1947, are included in the Circular.

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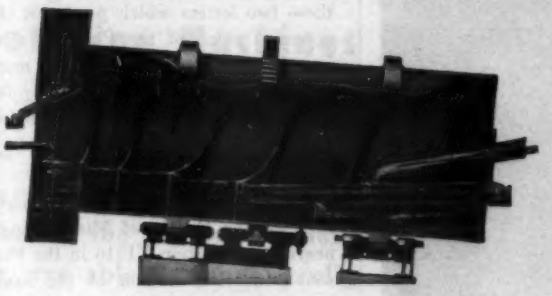
• CLEANER SANDS •



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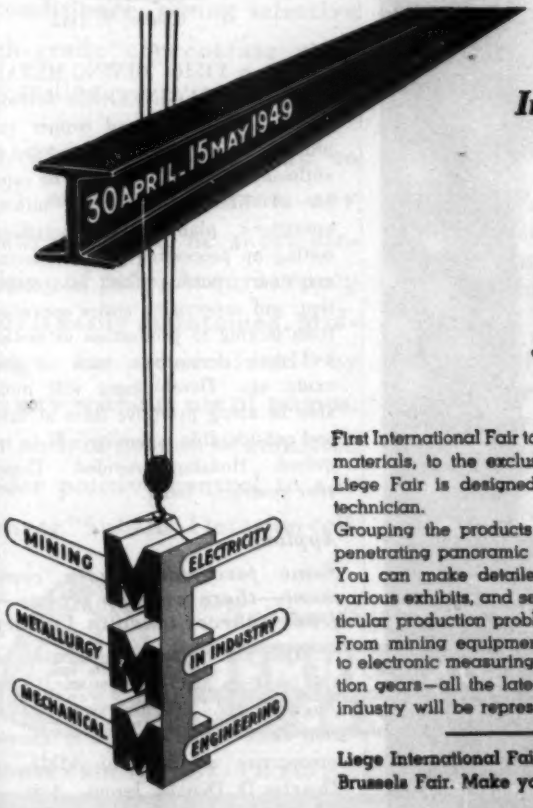

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Letters to the Editor

(*Continued from p. 12, Sect. 1*)

[We are in hearty agreement with these two letters which point out the potential value of the Ph.D. in mining. However, industry could do more to encourage young men to study for this degree and also provide suitable employment. *Editor.*]

May I suggest that you might have referred the Doctor of Mining Engineering to Position Y1516 in the Personnel Service column of the same issue. Kindly note that no mention is made of a staff or assistants in the job specification. Many of us know where, how, and who to get to make up a staff to meet such specifications but I doubt seriously if any one individual would claim that he could meet them as a single person. Since the Ph.D. you refer to might not know all this, he might possible actually do it, for the penalty of experience is to know what cannot be done and hence important things frequently fail to be accomplished.

HUBERT O. DE BECK
Consulting Geological Engineer
Custer, S. Dak.

Position Y1516: MINING-METALLURGICAL ENGINEER for development of zinc, lead and copper sulphide ores containing impurities of antimony and bismuth. Must be capable of directing layout of mining operations, planning transportation, setting up processing plant, ordering machinery, putting plant into operation, and supervising entire operation from mining to production of metals and their derivatives, such as zinc oxide, etc. Development will probably be along primitive lines at first, and considerable ingenuity will be required. Housing provided. Three-year contract. India.

Applause

Some favorable reader comment—there were no groans—from a survey taken in January

"You are to be congratulated on the make-up and contents of *Mining Engineering* . . . a first rate publication which should do much to interest prospective members of AIME."—Douglas D. Donald, Jerome, Ariz.

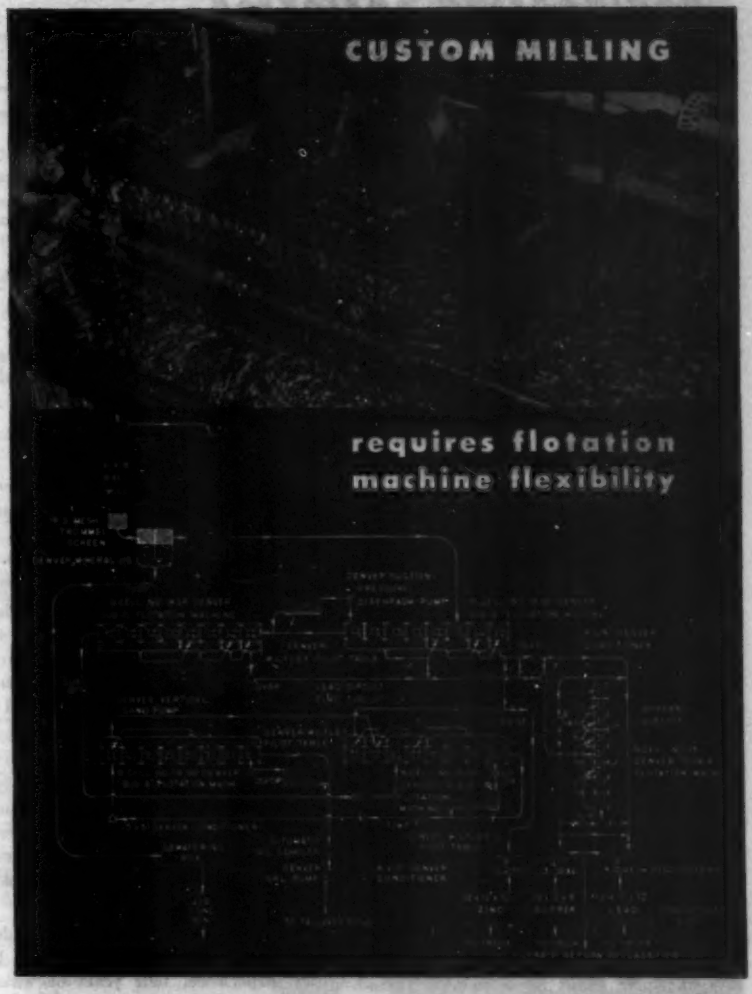
(*Continued on p. 50*)

Using Denver "Sub-A" Flotation Machines

... The American Zinc, Lead and Smelting Company at Ouray, Colorado, serving mines of the San Juan Triangle, are able to economically treat a wide range of complex ores in this 225-ton-per-day Denver Built Custom Mill.

FLOTATION FLEXIBILITY is the key to successful recovery of the many minerals treated. Any Denver "Sub-A" Flotation Cell, singly or in a bank, may be used as a rougher, cleaner, re-cleaner, or even as a conditioner, giving selective high-grade concentrate with low tailing.

COARSE MATERIAL (up to ¼") may be fed from any quadrant, with no short circuiting of pulp. Accurate pulp level is easily maintained. Middlings are recirculated by gravity without use of pumps. Air and/or gas can be admitted under positive control to any Denver "Sub-A" Flotation cell.



PRINCIPAL ORE MINERALS, recovered at this American Zinc Custom Mill by Denver "Sub-A" Flotation, cover a wide range and may vary considerably from hour to hour. These include:

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CHALCOPYRITE	
MARMATITE (ZnFeS)	GOLD AND SILVER BEARING PYRITES.
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You may read the complete story of this custom milling operation in Deco Bulletin M4-B51. Write for your free copy.

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When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary.

All replies should be addressed to the key numbers indicated and mailed to the New York office.

A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3.50 per quarter or $12 per annum, payable in advance.

Positions Open

METALLURGISTS, 2, 23-35, B.S. in metallurgy or mining; some practical experience necessary for one of them. In lieu of experience, graduate who specialized in ore-dressing problems would be acceptable for one of the jobs. Duties will be to conduct ore-dressing investigations (mainly flotation tests and microscopic examinations) in the re-research laboratories and supervising special tests in the concentrators. Must be single, or single status till housing is available. $2700-$3900. South America. Y798.

MINING ENGINEERS AND METALLURGISTS. (a) Metallurgist-mill foremen, experienced college graduates. Knowledge Spanish. Three-year contract. Starting salary, $5000 plus bonus and living quarters. Single preferred; if married, single status for 6 months. Transportation paid. (b) Junior metallurgist, graduate, with some experience in ore dressing and laboratory test work; single status. Standard 3-year contract; base starting salary $3000 plus bonus; knowledge Spanish desirable. Transportation furnished to Bolivia by air. Four weeks' vacation plus free living quarters. (c) Junior mine engineer, graduate, competent mine surveyor-draftsman; single status; 3-year contract. Starting salary $2700 plus bonus. Knowledge Spanish desirable. Transportation paid. (d) Mine foreman, graduate, experienced in metal mining; single status for six months. Three-year contract; starting salary $4800 plus bonus. Working knowledge of Spanish essential. Transportation paid to Bolivia by air for employee and wife. Four weeks' vacation a year plus free living quarters. Y988.

MINE SUPERINTENDENT with experience in cut-and-fill stoping, mine development, shaft sinking, maintenance. Must have fair working knowledge of Spanish and ability to handle labor. Salary, approximately $9600. Reply giving age, experience, etc. Latin America. Y1320.

ENGINEERS. (a) Mining engineer, young, 1 to 1½ years' experience at lead mine. (b) Engineer, young, for work in concentrating plant. Argentina. Y1925.

RESEARCH METALLURGIST, 30-40, graduate, with non-ferrous smelting and refining experience, to supervise development of hydro-metallurgical pyro-metallurgical and electrolytic refining methods. Salary, $4200-$4800 a year. Location, northern New Jersey. Y1926.

MINING ENGINEER, young, 2 to 5 years' experience, with good knowledge of mechanized coal mining. Will function as assistant to executive in New York office and as liaison between mines and the office. Salary open. New York City. Y1943.

MINE SUPERINTENDENT, graduate mining engineer, executive type, 10 years' experience, four years of which must have been in coal mining. Other experience in metal mining will be acceptable where coal mining methods have been used. Will be responsible for laying out plans, developing mechanization methods, etc. $7500. Wyoming. Y1949S.

METALLURGIST OR METALLURGICAL ENGINEER, young, B.S. degree, to study metals and processes used in electron tube development and manufacture. Tungsten, molybdenum, nickel, nickel alloys, copper and stainless steel alloys are the principal metals involved. Principal processes are work with the joining of metals by brazing and welding techniques. Location, southern New Jersey. Y2144(a).

SALES MANAGERS OR SALES ENGINEERS, 28-38, with engineering background and sales experience in pumps or closely related fields. Knowledge of manufacturing and handling of petroleum products helpful. Michigan. Y2168.

BUYER, 30-40, mining graduate, to buy machinery such as used in mining, power plants, textile mills or oil wells and ship it to clients. Should be able to handle exporting clearance papers, documents, etc. Must know South America and West Coast and must speak Spanish. Permanent. Good opportunity. Headquarters, New York City. Y2224.

Men Available

MINING ENGINEER AND GEOLOGIST, 40, married, no children. M.Sc. in geology. Twenty years' experience mine operation, mining and oil geology. Experienced in examinations, valuations, reports. Excellent record for production and labor relations. Fluent Spanish. Available May first. M-415.

MILL SUPERINTENDENT - MILL METALLURGIST, 44, married, B.S. in mining engineering, registered metallurgical engineer. Wide experience as operator, superintendent and in original research in complex lead-zinc-gold-silver-copper, gold and nonsulphide copper silver. Seeks permanent connection with responsibility. Prefers southwestern USA or Mexico. M-416-475-E-6-San Francisco.

M.B.A. IN INDUSTRIAL MANAGEMENT. B.S. in coal mining. Outstanding extracurricular activities. 26, married, no children. Five summers' experience in coal mines, 2 in time study. Some part-time selling experience. Desires industrial engineering with coal company or position selling mining machinery. Will locate anywhere n U. S. Available June 15. M-417.

MINING AND MECHANICAL ENGINEER, B.S. in both, 29. Registered in chemical. Some formal training in civil engineering and law. Six years' varied experience including research, design, construction, operation in connection with inorganic processes. Veteran, married, one child. Desires position with progressive organization as executive assistant or engineer. M-418-61-MM-Chicago.

MINING GEOLOGIST, 35, married, Ph.D. Six years' experience in mining geology and engineering, U. S. and Latin America. Willing to travel. Available 30 days' notice. Location immaterial. M-419-4510-E-1-San Francisco.

MINING ENGINEER, 33, B.S. and M.S. (U. of Pittsburgh), two years' post-graduate work and research toward Ph.D. at Columbia U; 4½ years' experience underground, specially in bituminous coal mines. Desires experience in planning improved methods in coal or

(*Continued on p. 50*)

OPPORTUNITIES

Address replies to: MINING ENGINEERING
29 West 39th St., New York 18, N. Y.

SMELTER FIELD ENGINEER for work large copper company, Chile, South America. 3-year contract. Transportation both ways and salary while traveling paid by Company. In reply give complete details.

Box D-6—MINING ENGINEERING

ASSISTANT CHIEF MINE ENGINEER for work large copper company, Chile, South America. 3-year contract. Transportation both ways and salary while traveling paid by Company. In reply give complete details.

Box D-7—MINING ENGINEERING

MINE FOREMAN, college graduate, experienced metal miner, standard three-year contract, single status or if married single status for six months, working knowledge Spanish essential, starting base salary $4800 yearly plus bonus one month yearly, free transportation to Bolivia by air for employee and wife, four weeks' vacation yearly, free living quarters.

Box D-9—MINING ENGINEERING

METALLURGIST-MILL FOREMAN, college graduate, experienced ore dresser and mill operator, standard three-year contract, starting base salary $5100 yearly plus bonus one month yearly, single status or if married single status for six months, working knowledge Spanish essential, free transportation to Bolivia by air for employee and wife, four weeks' vacation yearly, free living quarters.

Box D-10—MINING ENGINEERING

FIRST-CLASS ELECTRICAL DESIGNER for work large mining organization Chile, South America. General knowledge electrical applications and generation, transmission, and utilization of electric power desired. Must be familiar with installations for hydro-electric generating stations, substations, transmission lines, switchboards, industrial control, motors, hoists, and industrial electric railway equipment and know good deal of the theory involved in such applications. Should be able to turn out finished drawings with bills of material ready for the field, as well as work with office engineer in preparation of requisitions covering material involved in his drawings. 3-year contract. Transportation both ways and salary while traveling paid by the Company. In reply give complete details.

Box D-5—MINING ENGINEERING

Sales Engineers Wanted

Young men for sales work by manufacturer of heavy machinery. Knowledge of crushing, milling, and processing as related to mining and aggregate and cement production advantageous but not necessary. Qualified applicants afforded opportunity for rapid advancement. Give full particulars; age, education, previous experience in these industries and present position. All replies confidential. Our Sales Department has been advised of this advertisement.

Box D-8—MINING ENGINEERING

(*Continued on p. 48*)

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Dependable for Continuous Duty — Fully Automatic. Morse Drum and Disc Filters are highly regarded for satisfactory performance and low maintenance—made in a wide range of sizes to meet most all requirements.

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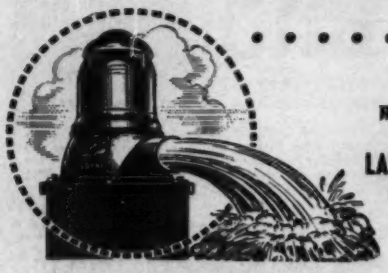

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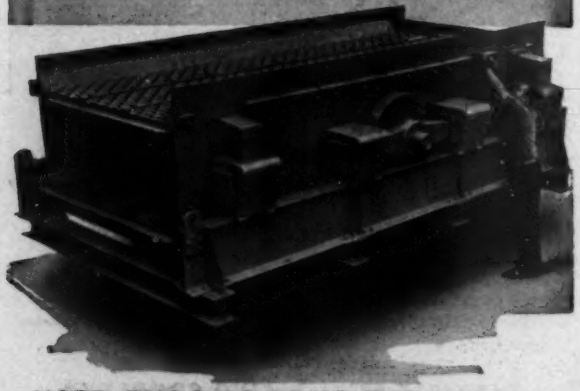

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OPPORTUNITIES

JUNIOR METALLURGIST, college graduate, some experience ore dressing laboratory test work, standard three-year contract, starting base salary $3000 yearly plus bonus one month yearly, single, knowledge Spanish desirable, transportation to Bolivia by air, four weeks' vacation yearly, free living quarters.

Box D-11—MINING ENGINEERING

JUNIOR MINE ENGINEER, college graduate, competent underground surveyor draftsman, standard three-year contract, knowledge Spanish desirable, starting base salary $2700 yearly plus bonus one month yearly, single, free transportation to Bolivia by air, four weeks' vacation yearly, free living quarters.

Box D-12—MINING ENGINEERING

Wanted: GEOPHYSICIST for teaching and research in active and well supported program. Professorship offered to properly qualified candidate. Ph.D. required. Also **STRATIGRAPHER** for medium-sized Geology Department. Assistant Professorship with opportunity for advancement. Ph.D. required. North Central region. Cite experience and references.

Box D-13—MINING ENGINEERING

Wanted: ASSISTANT MILL SUPERINTENDENT and **METALLURGIST** for lead-zinc flotation mill in Bolivia. Three-year contract. Annual salary $4500.

Box D-14—MINING ENGINEERING

Wanted: STAFF GEOLOGISTS (three) for operating mines in Bolivia. Underground and surface mapping, diamond drill supervision, outside studies. Latin American experience desirable. Preferably single. Salary up to $4500 annually, three-year contract.

Box D-15—MINING ENGINEERING

Wanted: MINING ENGINEER graduate, to operate tungsten mine in Bolivia, small production at present; carry on development program and expansion studies for increasing output. Previous South American experience essential. Salary dependng upon qualifications up to $4800.

Box D-16—MINING ENGINEERING

LABORATORY CRUSHER

Braun Chipmunk crusher, type VD with 1 HP motor $175.00

Braun Direct-driven Pulverizer, type UD with 2 HP motor. Excellent condition $175.00

HOOVER & STRONG, INC., Buffalo 1, N. Y.

FOR SALE: Allis-Chalmers Continuous Ball Mill, 8 in. dia. by 7 in. long, steel liner, complete with balls, drive, elevators, etc.

PERRY EQUIPMENT CORP.
1517 W. Thompson St.
Philadelphia 21, Pa.

(*Continued on p. 52*)

MANUFACTURERS NEWS • *Equipment—Bulletins—Personals*

Exhibit at 1949 Coal Show

The major features of the Armco Drainage & Metal Products, Inc., exhibit at the 1949 Coal Show in Cleveland, May 9-12, will consist of a corrugated metal fan duct, a STEELOX metal fan house and a liner plate mine entry or escapeway. Other items include ARMCO corrugated metal culverts, conveyor covers, corrugated metal ventilation pipe and air pressure pipe and couplings.

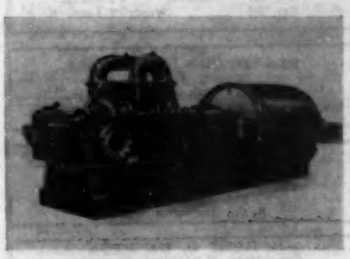
John T. Ryan Memorial Laboratory

The Mine Safety Appliances Co. is building the world's largest research laboratory to be known as the John T. Ryan Memorial Laboratory. This will be dedicated as a memorial to the late John T. Ryan, who with George H. Deike, president of the company, founded Mine Safety Appliances Co. in Pittsburgh 35 years ago. Facilities of the laboratory will be made available to all industry for the investigation of safety equipment problems affecting health and property.

Research and development efforts will be concentrated on instruments, equipment, and other devices to safeguard the health and welfare of workers in all types of industry. The world's most comprehensive library on safety equipment will be housed on the first floor of the new building and a complete machine shop to manufacture pilot models of instruments and appliances will be located on the ground floor.

Belt Conveyor Transportation System

H. B. Stewart, Jr., president of the Akron, Canton and Youngstown R. R., recently announced the formation of a new corporation, the Riverlake Belt Conveyor Lines, Inc., to build a $210,000,000 overland belt conveyor transportation system between Lake Erie and the Ohio River. The main line of the conveyor system, designed to handle bulk cargoes only, will be a two-way belt extending a distance of 103 miles from Lorain on Lake Erie to a terminal on the Ohio River.



New Boiler Feed Pumps

Worthington Pump and Machinery Corporation has announced the addition of four new boiler feed pump sizes to their line of centrifugal pumps. Two of the new sizes are 6-in. pumps and two are 8-in. pumps, which add to the range of possible applications for this type of service.

Kaiser Aluminum Shade Screening

A new type of aluminum screen that combines in one product the cooling action of an awning, the shading value of a venetian blind, and the insect protection of a fine wire mesh screen has been introduced by the Permanente Metals Corporation. This screening is given a special chemical coating that reduces glare and increases corrosion resistance. It is also rustproof, stainproof, and immune to rotting.

Automatic Line Oiler

A new line oiler that protects against running rock drills or other air actuated equipment without adequate lubrication has been manufactured by Gardner-Denver Co. In operation, the LO12 automatic line oiler delivers a carefully metered flow of atomized oil from any position, either vertical or horizontal and all of the oil is consumed.

Phenol Capacity Increased

The Dow Chemical Co. has announced completion of new facilities for expanding its phenol capacity by 30 million pounds per year. Dow instituted the manufacture of synthetic phenol in this country in 1915 and has long been top supplier of the important chemical which is used in especially large tonnage in the production of phenolic plastics, plywood bonding agents and other adhesives, and protective coatings.

Piezoelectric Gauges

For those who need to measure pressures of "instantaneous" or "explosive" nature, piezoelectric gauges are now available. The gauge works on the principle that when certain types of crystals are placed under sudden compressive stress, an electric charge is generated which is proportional to the stress. This charge

can be measured and the stress computed, or indicated by suitable instrumentation. For further information write to the Cambridge Thermionic Corporation, Cambridge, Mass.

Bulletins

Tractors. "Clearing for Action," a 15-page illustrated booklet published by the Caterpillar Tractor Co., Peoria, Ill., describes clearing methods for reclaiming productive agricultural land, construction sites, mine and quarry operations, and housing projects. Write for Form 11796 for copies.

Rotary Positive Blowers. A new Bulletin 22-23-B-13, on rotary positive blowers, has just been issued by Roots-Connersville Blower Corp., Connersville, Ind. This 20-page bulletin outlines in its foreword some of the principal uses for these blowers which had their inception in 1854 by the Roots brothers.

(*Continued on p. 50*)

(*Continued from p. 44*)

"I am quite delighted with the February issue."—Donald W. McGlashan, associate research professor, Montana School of Mines.

"I wish to compliment you on the first two issues of *Mining Engineering*. The new method of publication should meet with the approval of a great majority of Institute members. The sketches of Dr. Young and Mr. Myers, (January ME) and the article on Arizona's water that California is trying desperately to appropriate, were *very* good."—Brent N. Rickard, purchasing department, American Smelting and Refining Co., Tucson.

"Your papers are all excellent information on excellent subjects . . . and your arrangement would be hard to beat. The advertisements are most beneficial and valuable. I am now working to cut company costs, using more mechanical arrangements and re-arranging the plant. I look forward with interest to your next issue."—A. E. Hepburn, Denver.

"Due to the emphasis on mining, the new magazine will be of much more value in teaching mining engineering than its predecessor. It will be filling in a gap as only a society's publication can. I am enthusiastic about *Mining Engineering*."—Charles O. Frush, Iowa State College.

(*Continued from p. 46, Sect. 1*)

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Bulletins

Motor Starters. The Allis-Chalmers line of alternating-current full voltage starters to meet the requirements of any type of motor drive is described in a new 12-page bulletin released by the company. Construction features and uses of manual and magnetic across-the-line starters, across-the-line combination starters, reversing starters, and push-button control stations are all covered in Bulletin 14B7132.

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Mechanical Coal and Ash Handling. "How to Cut Small Boiler-Plant Costs by Mechanical Coal and Ash Handling" is the title of a publication issued by Bituminous Coal Research, Inc., Pittsburgh 22 or Washington 5.

Electric Shovels. The Harnischfeger Corp., Milwaukee, has released a new bulletin covering the P & H line of electric shovels. Printed in two colors and plastic-bound with a heavy cover, the booklet devotes 48 pages to pictures and features of the models 1400 and 1600 electric shovels. Bulletin X83-1 describes the many other features of these machines.

Personals

A. C. Hultgren, traffic manager of *Shell Oil Co.* for territory east of the Rockies since 1935, has retired after 21 years with the company.

G. W. Naylor has been appointed development manager for the Chemical Division of *Koppers Co., Inc.*, Pittsburgh.

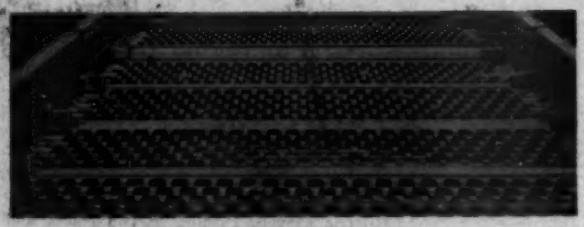
Arthur E. Stoddard was made president, on March 1, of the *Union Pacific R. R.*, with headquarters in Omaha, Nebr.

Mine Safety Appliances Co., Pittsburgh, Pa., has announced the addition of *Henry S. Carter* to the mining sales field staff in Bluefield, W. Virginia.

Eric Burkman, secretary of the *U. S. Rubber Co.* since 1929, died on February 26 while on vacation in St. Thomas, Virgin Islands. He was also secretary of the board of directors, the executive committee, and the finance committee.

Richard H. Kohler has been appointed advertising manager of the *Stearns Magnetic Mfg. Co.*, Milwaukee. *Hugh Sharp*, formerly advertising manager of this company, has resigned to join Advertising and Publicity Associates as account executive.

Fairbanks, Morse & Co. recently announced the following changes in the Sales Division. *O. O. Lewis* has been promoted to sales manager. *H. L. Hilleary* is being transferred from St. Louis to Chicago as assistant sales manager. *Donald T. Johnstone*, assistant manager of the Pump Division, succeeds *L. A. Weom* as manager of this division with offices in Chicago. *Mr. Weom* will become branch house manager in St. Louis.



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NEW TECHNICAL BOOKS

Thermique Pratique. By J. Grosso. Dunod, Paris. 1948. 142 p., diagrs., charts, tables, 8½ x 5¼ in., paper, 290 fr.
This book discusses methods for the most efficient use of coal. Following a presentation of the coal situation in France, economic combustion in individual furnaces is considered. Later chapters deal with the processes of furnaces, utilization of combustible gases, and thermodynamic characteristics of furnaces. It concludes with a description of the problem of evaluation of combustible solids.

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